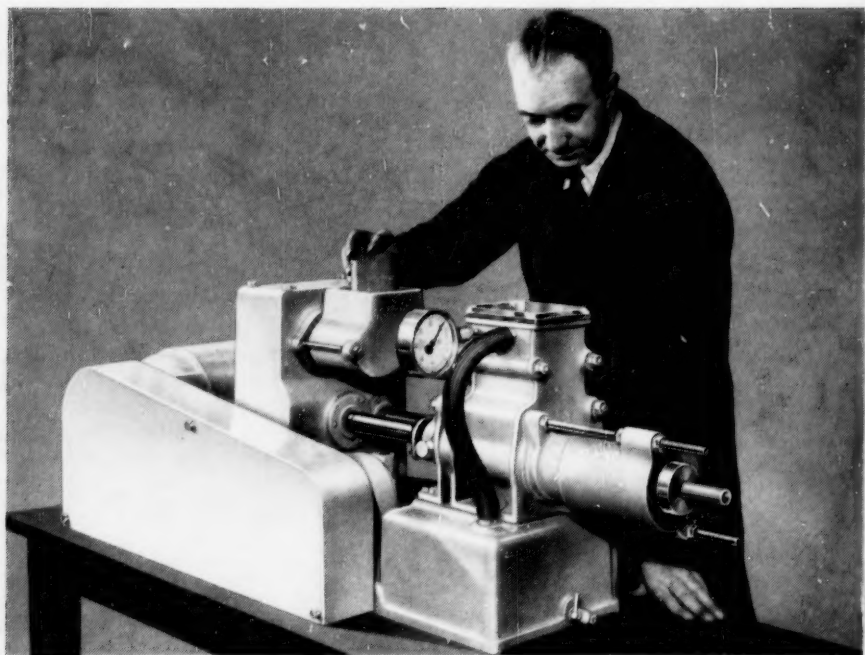


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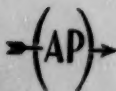
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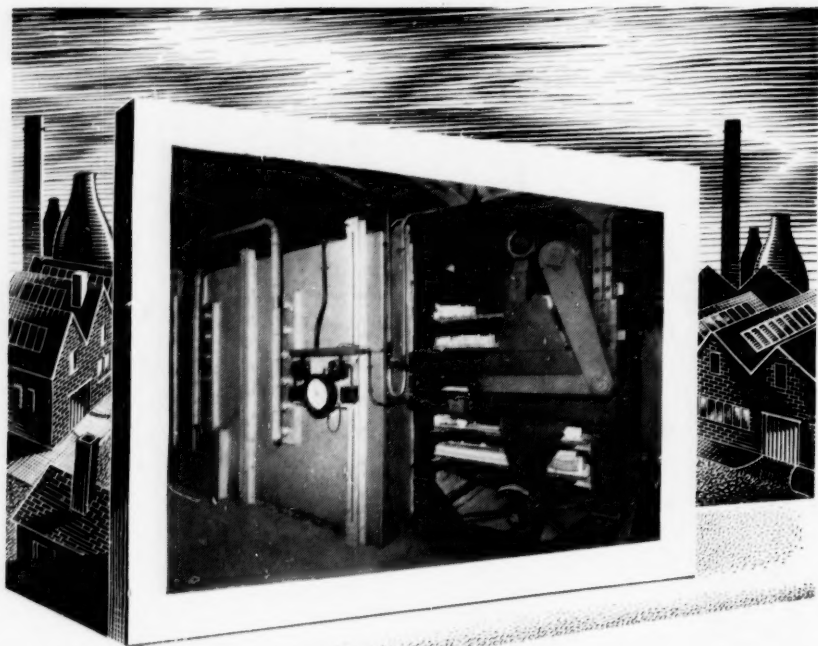
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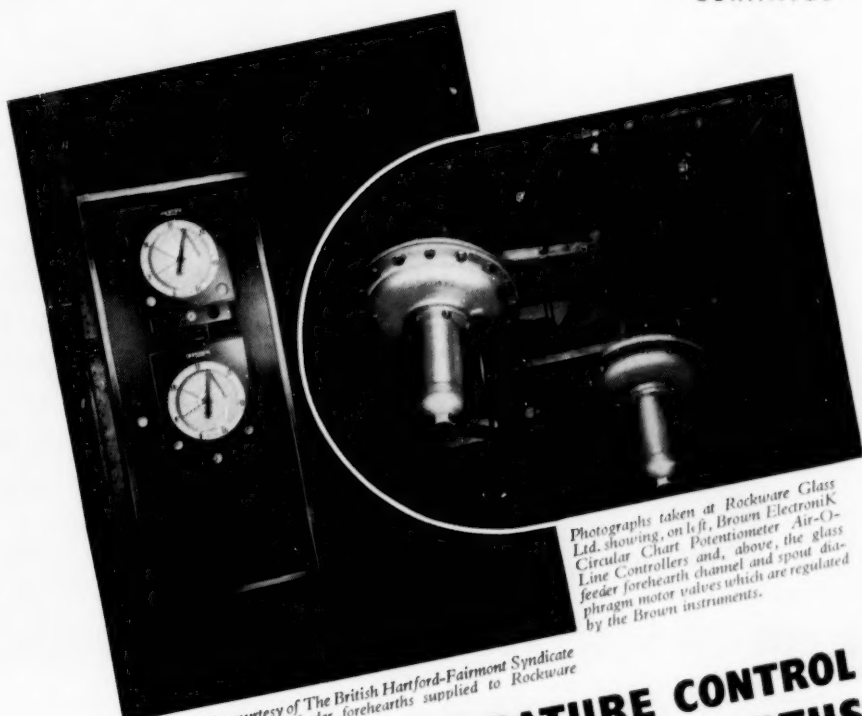
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Photographs by courtesy of The British Hartford-Fairmont Syndicate Ltd., makers of glass feeder forehearth supplied to Rockware Glass Ltd.

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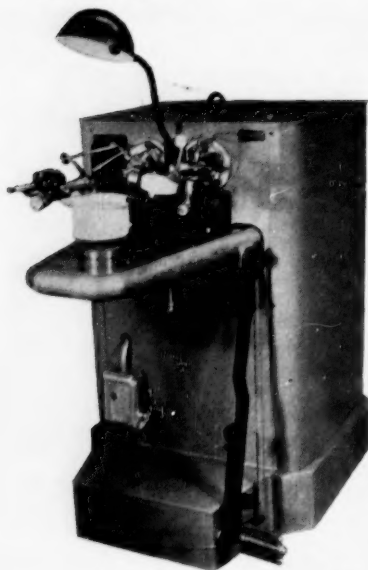
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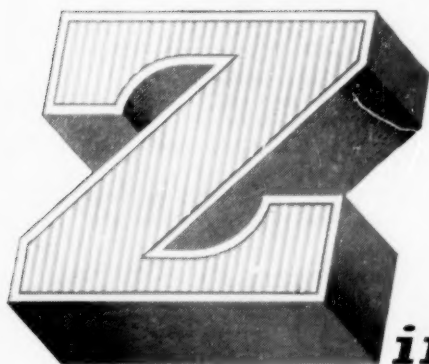
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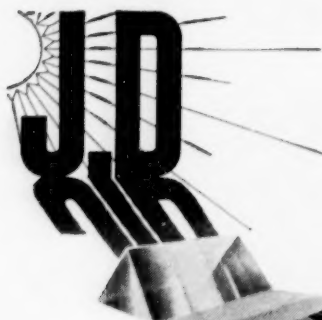
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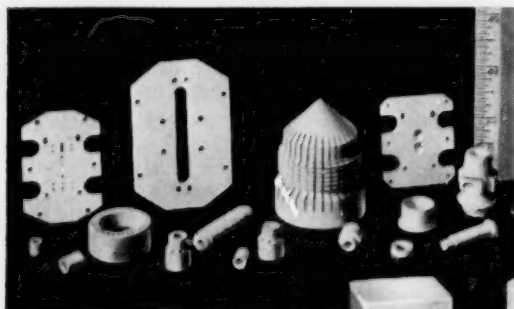


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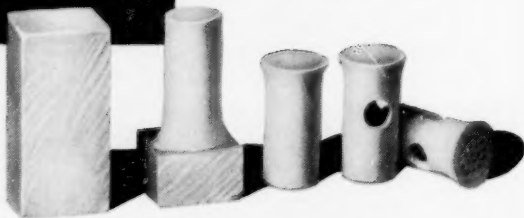


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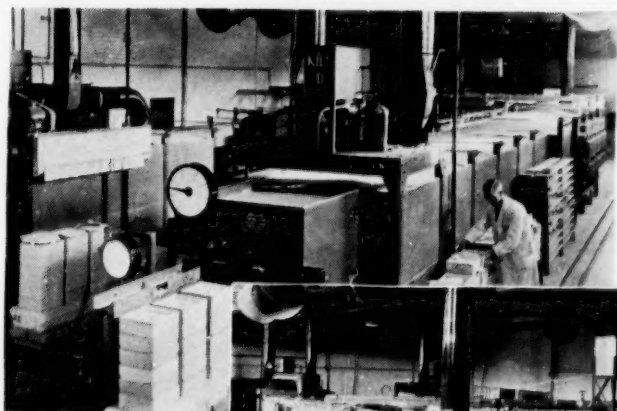


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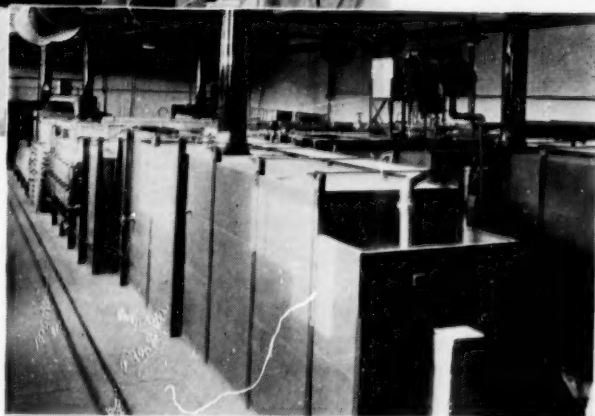
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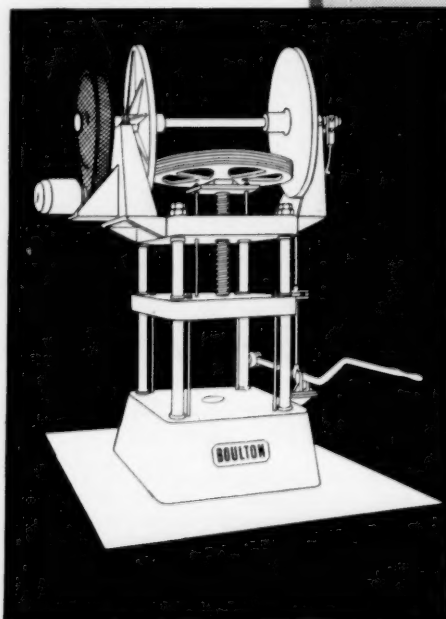
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CERAMICS

MARCH 1954

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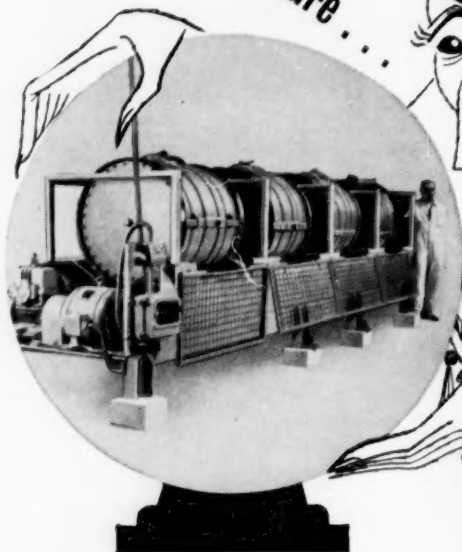
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Ceramics



VOL. VI

MARCH, 1954

NO. 61

The Alarming Prodigality of the Stoker?

A SUCCESSION of reports—of which the Ridley Report and “Fuel Conservation” issued by the Anglo-American Productivity Council may be selected—have stressed repeatedly the fantastic wastage of coal due to inadequate attention by stokers and boiler house staff. The latter report mentioned 120,000 Lancashire boilers consuming between them some 50 million tons of coal each year. There is reason to believe that these figures are an exaggeration, but undoubtedly the amount of coal wasted through bad firing and incompetent firemen is excessive even when considerable capital expenditure has been invested in modern plant and equipment.

It is, therefore, interesting to stress that courses in boiler house practice are available at some technical colleges throughout the country and certificates of proficiency are awarded by these colleges in the preliminary grades, and by the City and Guilds of London Institute for the intermediate and final grades.

To management it is important to stress that many boilers in this country at present are operated at an efficiency of 45 per cent. when they could, without any further capital investment, reach 65-70 per cent. Losses in output due to bad stoking have been anything from 20-30 per cent.

What is more important is that incentive schemes have been tried and have been operated very successfully based upon a variety of simple methods. The Fuel Efficiency Branch of the Ministry of Fuel and Power in the regions and at headquarters have advised in many instances.

If any manufacturer wishes further information a postcard to CERAMICS will ensure that the advice is forthcoming.

Unnecessarily reduced productivity is, in itself, bad enough, but for manufacturers to continue to pay unnecessarily high bills for coal is absurd.

The trouble is that very often higher management does not know and does not inquire as to how efficient their boiler installations might be, and if they troubled to make this simple investigation they might find a ready means of saving considerable sums on fuel per annum, with little or no capital outlay.

In our hard world this is about the nearest approach one can find of getting something for nothing!

Low Temperature Enamels and their Application to Aluminium

(SPECIALLY CONTRIBUTED)

IN applying enamels to metals the lowering of the maturing temperature presents attractions in that:

- (a) there is less danger of warping of the metal;
- (b) the cost of heating is less;
- (c) the possibility exists of applying vitreous enamel finishes to some non-ferrous metals of low melting point such as aluminium and some of its alloys which cannot at present be finished in this way.

There are certain difficulties, and it is true to say that all these have not yet been overcome, though research work is being pursued to this end.

The main trouble is that to produce very low melting enamels, such as required for aluminium, it is necessary to increase the fluxing materials and to introduce new ones. At the same time refractory materials must be reduced. It thus becomes difficult to maintain acid resistance, which is essential in modern cookers and other domestic appliances. Moreover, although lead oxide is a powerful flux and has been used in some formulae for low temperature enamels, its use in this country is attended with considerable restrictions, to ensure the health of the operators. For this reason lead is avoided, except possibly in some jewellery enamels, and manufacturers would be very loathe to start using lead enamels.

Use of Lithium Compounds

Lithium compounds have been found to exert a powerful fluxing action, and their incorporation in glazes and enamels has made possible the lowering of the melting point. Other advantages claimed are improved gloss, acid and scratch resistance in the enamel, and improved

fluidity at the melting point, so that holes in the enamel fill up more readily giving a smooth, bright, surface. As with the other alkali oxides Li_2O gives the enamel a higher expansion coefficient.

At the moment supplies of lithium compounds are difficult in this country. Lithium carbonate is the material commonly used, prepared from the natural ores lepidolite (lithium potassium aluminium fluosilicate) and spodumene (lithium, aluminium, silicate).

W. M. Fenton and D. A. Huppert (*Proc. Inst. Vit. Enam.* 9, 84, 1947-50) have given a bibliography on the use of lithium compounds in enamels, and have also described experiments on using a number of lithium compounds in ground and cover coats. Lithium manganite, $\text{Li}_2\text{O} \cdot \text{MnO}_2$, and lithium cobaltite, LiCoO_2 , could be used in place of manganese dioxide and cobalt oxide in ground coats, e.g., anhydrous borax 25.7 per cent., feldspar 21.6 per cent., quartz 29.8 per cent., soda ash 9.2 per cent., sodium nitrate 5.1 per cent., fluorspar 6.2 per cent., lithium manganite 1.5 per cent., nickel oxide 0.6 per cent., lithium cobaltite 0.3 per cent.

The results indicate an increase in fluidity, which permitted a reduction of firing time and/or a lowering of temperature. The thickness of the applied coat could be lowered. There was improved adherence at lower temperatures, and under these conditions it was possible to use a lower grade of steel without blistering. Where it is not convenient to change the frit batch, the lithium compounds can be added at the mill. 1 per cent. lithium manganite lowered the melting point of some frits 30°F . to 70°F . Alternatively the addition of 0.5

per cent. to 0.75 per cent. made the enamel smoother and more easily worked at the same firing temperature.

In single coat acid resisting finishes 2 per cent. of lithium manganite added to the first batch lowered the firing temperature 50° F. Other lithium compounds useful in single coat finishes and ground coats are the cobaltite, silicate, titanate, zirconate, and lithium zirconium silicate. All the above except the silicate can also be used as mill additions. They reduce firing temperature, and also cut the firing time. In titania opacified cover coats the story was much the same. Obviously in white and similar finishes the manganite and cobaltite cannot be used. The silicate and titanate and lithium zirconium silicate were useful giving either shorter firing times, or reduced firing temperatures. This was achieved without loss of other properties.

Enamel Finishes on Aluminium and its Alloys

In a paper read at the 1950 Spring Meeting of the Institute of Vitreous Enamellers, R. P. Fraser, A. L. Chianchi and J. M. Cannor (*Proc. Inst. Vit. Enam.* 10, 16, 1950-2) pointed out the enormous rise in the world production of aluminium. From a figure of 3,000 tons in 1935 it had risen to 1,250,000 tons in 1948. Of this total the U.S.A. contributed 46 per cent., Canada 27 per cent., U.S.S.R. 10 per cent. and France 5 per cent. Far and away the greatest consumer was the U.S.A. with 640,500 tons, with Great Britain next with 246,000 tons.

Being light and rust free, aluminium and its alloys have attractions as materials of construction, and their use has spread for domestic equipment as well as in aircraft, shipping and other forms of transport. At present the finishes available are various stoving enamels and dyed oxide coatings prepared by anodic oxidation. Neither of these will withstand heat without, at any rate, loss of colour. Attention has therefore been directed, especially in America, to developing enamel coverings for aluminium and its alloys.

The advantages claimed for enamelled aluminium are:

1. Excellent weathering properties;
2. Light weight;

3. Absence of corrosion if accidentally chipped;
4. It can be cut with a hacksaw for assembly.
5. High impact and thermal shock resistance.

Where enamelled panels are used for constructional work, and this is done in the U.S.A., though not as far as is known over here, these advantages are real, and possibly account for the commercial development of enamelled aluminium there. While development work has proceeded in this country, to date enamellers have shown no great interest in using aluminium in preference to steel for the kind of ware that is most in demand in this country.

Conditions to be Satisfied

In order that any enamel may adhere satisfactorily to aluminium and its alloys it must have a higher coefficient of expansion than those normally used on iron and steel. R. P. Fraser and co-workers (*loc. cit.*) give the expansion coefficient of aluminium and its alloys as $24-28 \times 10^{-6}$, while for iron and steel the values are $11-16 \times 10^{-6}$ over the range 0° C. to 600° C.

According to these authors the enamel for use on aluminium would require an expansion coefficient of $18-22 \times 10^{-6}$ as against $7.7-11 \times 10^{-6}$ in iron enamels. Fortunately the enamels will also have to be very fusible and this helps in the problem of increasing the expansion characteristics. Moreover, the melting point of aluminium and its alloys is around 570° C. to 600° C. with an annealing temperature of 350° C. to 600° C. The melting point of the enamel would therefore have to be in the region of 500° C. to 550° C. as compared with temperatures ranging from 700° C. to 850° C. and higher for iron and steel enamels.

Adherence

Adherence is another factor to be considered. Very thorough cleaning treatment is required to enable good adhesion to be obtained with iron and steel. The preparation of aluminium for enamelling should not be more complicated and, if pretreatment of the metal could be simplified, so much the better. Finally the finish should

CERAMICS

stand up to the usual wear and tear, and be resistant to the usual domestic scourers and fruit juice acids, etc.

Lead Enamels

The first process for enamelling aluminium employed enamels high in lead and alkalis, since this combination gave low melting enamels with high expansion. The original patent was taken out in 1917 (K. Wurga U.S. Pat. 1230958 June 26, 1917; see also U.S. Pat. 1346475 May 27, 1919; Swiss Pat. 79,967, 85,577, 1919) but commercial application was not begun until comparatively recently.

The Dupont Patents (Brit. Pats. 580688 and 580689) give examples of the lead bearing type of frit (c.f. Vitreous Enamels, Borax Consolidated Ltd.).

	1.	2.
Boric acid ...	13.6	8.3
Silica ...	18.1	27.1
Titania ...	9.8	9.4
Soda ash ...	18.9	16.2
Lithium carbonate	—	5.7
Potassium carbonate	9.4	12.5
Red lead ...	30.2	20.8

To these may be added zirconia and antimony oxide and ceramic pigments. Colours available were red, brown, black, buff, white, and several yellows, blues and greens. The range of compositions of the finished coating covered by the patents was PbO 25 per cent. to 65 per cent., SiO₂ 20 per cent. to 35 per cent., TiO₂ 1 per cent. to 15 per cent., one or more of alkali oxides Na₂O, K₂O, Li₂O up to a total of 10 per cent. to 13 per cent. (Li₂O not more than 9 per cent.), possibly with additions of up to 10 per cent. B₂O₃, up to 7 per cent. ZrO₂, 0.5 per cent. to 5.0 per cent. Sb₂O₃, and 1 per cent. to 15 per cent. of colouring oxide (c.f. J. C. Bailey and M. E. Whitaker, *Light Metals*, 12, 139, 1949). These enamels employed a ground coat under the coloured finishing coat.

Metal Preparation

These lead and titanium containing enamels needed special cleaning and preparation before enamelling. Details of a process were given in an article in *Ceramic Industry*, Jan. 1949. This involved degreasing in trichlorethylene vapour followed by chemical treat-

ment. In this case the metal was treated with 6 per cent. sulphuric acid (with $\frac{1}{2}$ per cent. wetting agent) at room temperature for 15 minutes. It was then treated with an alkaline bath made from: 0.02 lb. chromic sulphate, 1.00 lb. chromic acid, 1.19 lb. sodium hydroxide, 8.00 lb. water, for 4 ± 1 minutes at $120^\circ \text{F.} \pm 5^\circ \text{F.}$, followed by rinsing and drying.

This treatment was considered essential to form a good bond.

Lead containing enamels for aluminium have been produced in this country, but owing to patent protection titania has had to be omitted, and in the early formulations lithium compounds, which were expensive, were also left out. No preliminary surface treatment was required. The resistance to alkalis and water of the earlier types was poor, and in subsequent formulations this was corrected by alterations in composition at the expense of somewhat higher firing temperatures. Details of these are given by Fraser and co-workers (loc. cit.).

APPROX. MOLAR PERCENTAGE OF LEAD-BEARING ENAMELS FOR ALUMINIUM.

	Aluglas*†	A	B	B.1
PbO	40-50	25-35	10-20
SiO ₂	20-30	30-40	40-50
Li ₂ O	0-1	0-3	0-3
Other alkalis R ₂ O	...	5-7	9-12	12-16
B ₂ O ₃	15-20	10-15	8-10
Al ₂ O ₃	1-3	1-3	2-4

*"Aluglas" A, B, and B.1. Brit. Pat. Application No. 37,078, 1946. †"Aluglas" is the trade-mark of Amalgamated Research and Development Co. Ltd., for their frits.

These were opacified by molybdenum compounds. Ammonium molybdate was added to the batch and ammonium, sodium and calcium molybdates were added in addition to the mill batch. Zircon can also be added at the mill (Brit. Pat. Application No. 14,774, 1948).

Experiments with lead bearing enamels seem to indicate that simple cleaning is sufficient to ensure a good bond, the aluminium oxide film promoting good adherence (Bailey and Whitaker, loc. cit.). With certain types of lead-containing enamels it appears to be the practice to use metal pre-treatment as an insurance in production in the manner outlined above.

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Pickling of castings in caustic soda is recommended to remove surface skin, which does not give good adhesion.

Leadless Enamels

Lead enamels suffer from the disadvantages that:

- lead is poisonous and this limits the application of such enamels. Moreover, factories employing lead compounds must conform to strict regulations designed to protect work people;
 - their resistance to chemical attack is limited;
 - stability of colours varies and special frits must be used for certain colours;
 - certain alloys cannot be enamelled with existing frits;
 - In some cases metal preparation must be done before enamelling.
- Successful attempts have therefore been made to evolve leadless enamels suitable for aluminium and its alloys.

These have proceeded along two lines. In one type of frit produced in this country ("Aluglas D") the lead

oxide has been replaced with oxides of the alkaline earth metals, while maintaining the possibility by the use of alkali metal oxide (including lithia) and boric oxide. These "Aluglas" frits can be applied direct to commercial sheet aluminium and a number of the more important wrought and cast alloys.

In those alloys with fairly large percentages of copper and magnesium special undercoats are employed to promote adhesion. Development work is still proceeding in this field.

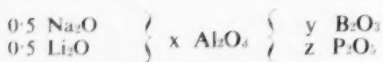
Low Temperature Phosphate Enamels

The other type of development is the use of phosphate enamels. Development of this has proceeded in this country and in the U.S.A.

Early attempts at leadless enamels were based on silicate-borate glasses and in many cases the maturing temperature was too high. J. W. Donahey, G. J. Morris and B. J. Sweo have described phosphate base glasses as enamels for aluminium (*International Enamellist* 1, [4], 6, 1951).

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The compositional limits are defined by a formula:

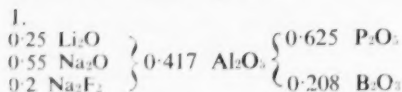


in which $x+y+z \geq 2.0$ approx.

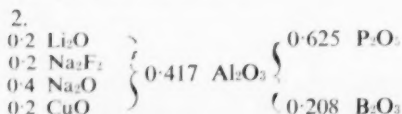
x does not greatly exceed z

$(x+y)$ does not greatly exceed $2z$.

The following was used as a base for Al enamel compositions:



By itself this gave severe boiling due to reaction of frit with the aluminium. This was overcome by using a ground coat of:



The application of a ground coat required preliminary cleaning and etching. An alkaline or acid bath at 220° F. gave satisfactory results. It contained tetra sodium pyrophosphate, sodium sesquicarbonate, and wetting agents. Three minutes immersion at 220° F. gave a clean etched surface. The acid bath recommended contained 5 per cent. sulphuric acid and the metal was immersed in it for 5 minutes at 220° F. followed by the usual washings. Large castings were degreased by firing to 900° F. and then sandblasted.

Clay Unsuitable for Suspension

Clays are unsuitable for suspending the frit as their presence increases the maturing temperature and the result is a poor immature enamel at the required firing temperature. Donahey, Morris and Sweo recommended sodium silicate as a suspending medium, and give a typical mill batch as follows:

- 100 frit (by weight)
- 2 sodium silicate (by vol.)
- ¼ sod. tetrphosphate (by weight)
- 35 water (by weight)

The ground coat mentioned above was applied in one application at approximately 30 grams per square foot of surface (dry weight). Its colour is a transparent blue-green.

All cover coats were based on the composition (1) above. Opacifiers were added at the mill and 10 per cent. titania additions gave a white with 75 per cent. reflectance. For cover coats the sodium tetraphosphate was replaced by the same amount of potassium chloride for set up agent. The usual colouring oxides could also be added.

The phosphate enamels resisted scratching by a penknife. Acid resistance was satisfactory for most indoor applications. At present an improvement in resistance to weathering is desirable and this angle is being followed up. Laboratory tests indicated that the alloy used has little effect on the properties of phosphate enamels.

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EXCLUSIVE**"Ceramics—A Symposium"****An Appreciation**

by L. R. BARRETT, M.A., B.Sc., M.S. A.R.I.C., M.Inst.F.

(Lecturer in Refractories and Silicate Technology at the Imperial College of Science and Technology)

PART 2.*Clay—Mineralogy*

IT is now over twenty years since the broad features of the structure and classification of the various clay minerals were established by Bragg, Pauling, Ross and Kerr, Grim, Bradley, Gruner, Hofmann, Endell, Wilm, Marshall and many others. The soil chemists have made more use so far of this information than ceramic workers, as is perhaps natural since the former are only interested in the clay in its natural state, whilst the latter have to give a good deal of attention to the clay as a source of refractory and fluxing materials on pyrolysis. However, a number of fields come to mind where a detailed knowledge of the physiognomy of clays is likely to earn dividends: foundry moulding, slip-casting and in setting up glazes and enamels for instance.

According to our present knowledge china and ball clays consist largely of kaolinite, though N. O. Clark (1950) has indicated montmorillonite (the basis of bentonite) is to be found in the former. Halloysite predominates in some clays. G. W. Brindley and A. L. Roberts and co-workers at Leeds have shown that British fireclays contain a mineral rather like kaolinite but less well crystallised, which has been given the name livesite after the Livesey chair at Leeds which A. L. Roberts occupies. The leadership exercised by G. W. Brindley in the field of clay crystallography will be missed here now that he has joined the staff of the Pennsylvania State College. Another Leeds man who migrated to the U.S.A. was C. E. Marshall.

There are three contributions on clays in the first part of the "Symposium." G. W. Brindley and D. M. C. MacEwan have compiled a work of reference on the structure of clays and related silicates which can be used to supplement "X-ray Identification and Crystal Structures of Clay Minerals" published by the Clay Minerals Section of the Mineralogical Society in 1951, and edited by Brindley and to which MacEwan contributes. These two workers have an international reputation in this field. The Editors of the "Symposium" are to be congratulated on securing this important contribution.

The tubular habit of halloysite is now well established by electron microscopy. This is ascribed to the misfitting of successive layers which bend over like books piled with their backs together. Well dispersed chrysotile fibres also show this effect probably for the same reason. Brindley and MacEwan are not inclined to accept the calculations of T. F. Bates and co-workers (1950) of the tube diameter, but concede that lattice strains are the cause of the curling.

The small but finite cation exchange capacity of kaolinite may not be entirely due to unsatisfied valencies at the edges of broken tabular crystals as supposed by W. P. Kelley and H. Jenny (1936) but to isomorphous replacement of silica by alumina in the lattice as in the case of montmorillonite.

Clay as a Colloid

D. A. Holdridge contributes a balanced review of the colloidal aspects of clay technology. He points

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out in conclusion that "colloidal reactions are complex and adequate knowledge can only be attained by adequate scientific training." In short, if the ceramic industry is to make the best of clays used as colloids, fully trained personnel are necessary to replace the all too frequent "rule of thumb" control.

The Action of Heat on Clays

The perennially interesting subject of the action of heat on clays is taken up by J. F. Hyslop, who has made several valuable contributions in this well-worked field during the past thirty years. He says quite rightly that a whole volume could be written but satisfies himself with twelve pages in which dehydration, recrystallisation (of γ -alumina and mullite) and vitrification are considered.

Dehydration has been shown by P. Murray and J. White to be of the first order type with an energy of activation for kaolin clays of about 36 k.cal per gm.mol. of water vapour. The reaction is appreciable at about 400° C. as H. F. Houldsworth and J. W. Cobb showed in 1923 but only becomes fast at about 550° C. Consequently there has been some difficulty in correlating the temperatures at which certain percentages of the change occur in different types of experiment, since few workers use all possible methods, e.g., differential thermal analysis has been favoured in recent years where fast rates of heating are used, whereas, formerly, loss of weight on dehydration with slower rates was favoured. Hyslop has favoured thermal expansion measurements to follow the reaction.

There has been for a long time controversy as to the nature of dehydrated clay. J. W. Mellor was of the opinion that a mixture of alumina and silica was left, but many Continental workers believed a compound "meta kaolin" was left, a view towards which Hyslop leans. The difficulty is that the "meta kaolin" is amorphous. Hyslop shows that in specific gravity, refractive index and solubility of the alumina in hot dilute hydrochloric acid, "meta kaolin" and alumina-silica glass made by firing clay in an oxy-acetylene flame are very similar, but one would not expect a layered though disordered

arrangement of alumina and silica to be identical with isotropic glass.

Phase Relationships in Ceramics

The remaining contributions in the general section are by James White on phase relationships in ceramics. For its likely influence on future ceramic research it is most significant. This is the first time that modern concepts in physical chemistry have been brought to the notice of ceramists in a connected way with examples of their use. White's interest in and command of the subject springs from his training at the Royal Technical College, Glasgow, under Professor R. Hay, whose school has been responsible for much valuable fundamental work on silicates. Two other authors, J. F. Hyslop and W. A. Archibald are fellow alumni. As White puts it "in studying the behaviour of materials at high as at low temperature we are concerned with finding the answers to two main questions: (1) what is the equilibrium state to which a material is tending under the conditions to which it is subjected and (2) at what rate does it tend towards the equilibrium state under these conditions?" The first is answered by chemical thermodynamics, in particular that the Gibb's Free Energy tends to a minimum at equilibrium. The answer to the second question is decided by the proportion of "activated" atoms or molecules, i.e., those with a certain minimum quantity of energy. White's contribution deals with the first question and begins by expounding the nature and use of the Phase Rule, since equilibrium in ceramic systems is generally concerned with several phases, e.g., crystals, liquids and vapours. For some years now the American Ceramic Society has done a great service to ceramists everywhere by compiling phase-equilibrium diagrams, many of the most important having been worked out in the U.S.A. This "Symposium" of the British Ceramic Society repays our debt.

The Fourth International Ceramic Congress.—The Fourth International Ceramic Congress will take place in Italy this year from the 27th September to the 2nd October.

Ceramics for High Temperature Applications

by ALEXANDER PECHMAN*

THE advent of the modern jet-type power plant for aviation has greatly accelerated the development of new high-temperature ceramic materials. These power plants are essentially high-temperature engines which convert heat energy into work. The greater the differential in temperature of the air between the beginning and end of the conversion, the greater the efficiency of the engine. Consequently, turbo-jets, gas turbines, ramjets and rockets have created a demand for materials which will withstand elevated temperatures and vibration and possess good resistance to thermal shock. Ceramic materials seem to offer the best promise of providing these desirable characteristics.

At the present time, special metals are meeting the requirements in the high-temperature applications of aviation. The Ryan Aeronautical Company utilizes many of these alloys in building combustion chambers, transition liners, exhaust cones, tail pipes and afterburners for jet engines as well as piston engine exhaust systems, rocket motors and other similarly tortuous components. Stainless steels, Inconel, Inconel X, Hastelloy C, Haynes Stellite No. 25, N-155 and other alloys are being used in these Ryan-built products.

However, many metallurgists question the capacity of the metals for performing their roles at temperatures higher than those now experienced, 1,800° F. This point seems to be about the limit of endurance for most metals now known. Unfortunately, the metals with the highest melting points decompose rapidly in air and are thus rendered useless in such applications. For instance, tungsten,

with a melting point of 6,200° F. oxidises readily in air at temperatures far below this point and molybdenum, with the melting point of 4,750° F. decomposes at 1,200° F. For the same reason, other high melting point metals, such as columbium, tantalum and zirconium, cannot be used.



The author—Mr. Alexander Pechman

Ceramics, on the other hand, have no definite melting point but gradually deform under stress at elevated temperatures. They can be used as ceramic bodies, ceramic coatings for metals or in combination with metals, as cermets.

All ceramics are produced by firing materials at high temperatures. A number of basic reactions always occur before the end product is obtained. In the manufacture of pottery and refractories, whose principal ingredient is clay, the following changes take place:

1. The mechanically held water is removed and chemically combined water is dispersed as the clay

*Ceramic engineer, Ryan Aeronautical Company.

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minerals break down. When the chemically combined water is removed, the ceramic loses its plasticity and the material becomes a hard mass, shrinking during this phase.

2. Crystalline changes occur during the entire heating process, resulting in the creation of crystal forms which give the fired piece its mechanical strength and other final properties. For example, crystalline changes in the alumina and silica, the main constituents of clay, result in the formation of mullite. In steatite bodies, which are basically 90 per cent. talc and 10 per cent. feldspar, enstatite crystals are formed.

glass, such as lead oxide and borax; and those which are refractory alone, but by eutectic combinations produce glasses readily, such as magnesium, zinc and barium oxides.

Although the reactions of ceramics at high temperatures are not completely understood, it is known the fluxes are important in the making of a non-porous body. The analysis of phase diagrams of various systems generally reveals what is occurring in ceramic reactions during the firing procedure and is the basis for ceramic science in the development of new formulations. But, in complex bodies, containing several types of oxides



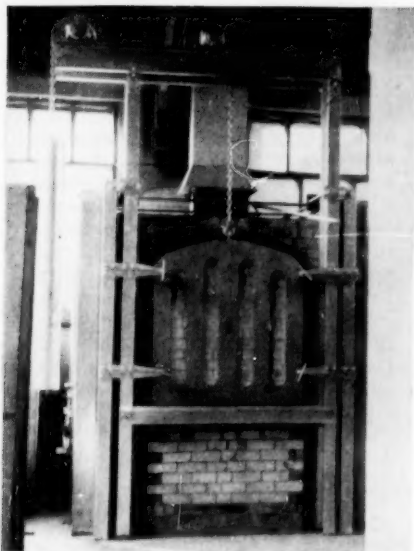
View of the Ryan production area showing the attachment of precision flanges to ceramic coated exhaust sections for Pratt and Whitney engines. The company is the only producer of ceramic coated components, in volume, for the aircraft industry

3. All combustible substances are burned and the carbonates, sulphides and sulphates are decomposed. Most clays contain calcium, magnesium and iron. During this period the compounds of these elements are oxidised. Iron oxidises to the familiar red colour seen in brick. Vegetative matter, such as wood, leaves and other carbonaceous material, is removed.
4. The most fusible ingredients melt and the molten liquid attacks the unfused material, taking it into solution. These fusible ingredients are called "fluxes." There are two types: Those that form a glassy phase which reacts with more refractory materials to form more

besides alumina and silica, each reacting with the other as a flux or refractory, no complete picture of the reactions has yet been presented.

5. The liquid formed fills all of the pores, making a dense rock-like piece. Ceramic bodies possess a vesicular structure which allows the removal of water and gases during firing. The molten liquid formed gradually fills all of the pores and capillary systems in the final vitrification period.
6. The resultant crystalline structure formed during the firing gives the ceramic its major strength. Needle-like crystals of mullite are formed from alumina and silica and, with

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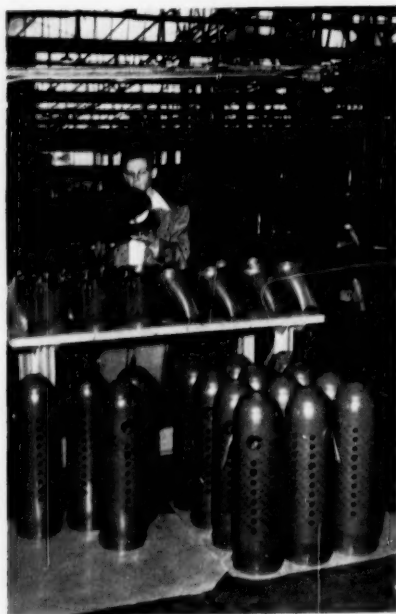
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higher temperature firings, will result in the forming of corundum. Excess silica present is in the form of cristobalite and tridimite.

In designing ceramic bodies for specific purposes, one ceramic oxide is used as the principal portion of the composition, such as is illustrated by the steatites. The enstatite crystals, formed through firing, give the body its excellent electrical properties.

The demand for refractories which would withstand high temperatures resulted in the development of pure oxide refractories, or those composed of a single refractory oxide. This type is free from the fluxing effect of lower temperature oxides ordinarily found in a ceramic body and the resultant refractory is monocrystalline and self-bonded in form. Impurities in the ceramic lower the melting points and strength at high temperature. For example, strontium, barium and calcium oxides hydrate at elevated temperatures and chromium and nickel oxides are easily reduced at high temperatures.



Ryan ceramic coatings are given a last minute inspection before these transition liners and inner combustion chambers, for General Electric J-47 jet engines, are shipped to the General Electric Company

The main types of pure oxide refractories are:

1. *Alumina*—This oxide has a fusion point of approximately 3,700° F. with a practical upper working limit of 3,400° F. It has high mechanical strength, is relatively inexpensive and is stable in both oxidising and neutral atmospheres. It is used in the form of crucibles and tubes.
2. *Magnesia*—This refractory has a fusion point of 4,532° F. but possesses low resistance to thermal shock and reduces readily at high temperatures. Magnesia refractories are used almost exclusively in the form of brick for the bottoms of basic, open-hearth furnaces and for surfaces which come into contact with molten metal and slag. Magnesia refractories cannot be used in highly reducing atmospheres above 3,100° F.
3. *Zirconia*—Zirconia melts at 4,919° F. Because of its predisposition to abrupt crystalline volume changes, zirconia refractories are usually stabilised with lime or magnesia which reduces its softening temperature. This type of refractory has a low coefficient of thermal conductivity and displays better insulating properties than fireclay brick. Its stability in reducing atmospheres is fair. Zirconia crucibles have been used in laboratories for special melts at temperatures up to 4,725° F. The low electrical resistivity, at elevated temperatures, of stabilised zirconia refractories permits its use as an electrical heating unit.
4. *Beryllia*—In pure form, beryllia melts at 4,568° F. It is very resistant to reduction, has high thermal conductivity and, consequently, good thermal shock resistance. Beryllia is dangerous to use because it is extremely toxic to the respiratory system.
5. *Thoria*—This is the highest temperature oxide known, melting at 5,072° F. It is extremely heavy and possesses poor shock resistance. It is radio-active and presents problems in fabrication. Like beryllia, the oxides of thorium are expensive and their general use in industry in bulk form is limited.

In general, ceramic materials possess good strength in compression and deform gradually, under temperature, without displaying a definite melting point. Metal compounds are ductile and can withstand mechanical shock. By combining ceramic and metallic refractories, a product which has the advantage of both may be achieved.

The need for protecting metals against the ravages of high temperature arose during the last war. In the early 1940's, a critical shortage of such essential materials as nickel, cobalt, tungsten, tin, columbium and others occurred because the importation of these ores was suddenly cut off. The demands for these alloy constituents increased. It was necessary to find a ceramic coating for low carbon steels, such as S.A.E. 1020, which would permit their use in place of stainless steel in applications of the type of exhaust systems for internal combustion aircraft engines. The National Bureau of Standards began an investigation of enamel coatings to find one which would protect low carbon steels from high temperatures and would resist thermal shock and the effects of thermal gradients.

By 1943, the enamelling section of the Bureau of Standards, under the direction of William N. Harrison, developed a coating known as A-19—basically a refractory ground coat. A-19 was used throughout the aeronautical industry, giving protection to mild steels up to temperatures of 1,250° F. Further research evolved the coating of A-418, now in general use, which protects stainless steels to temperatures of 1,700° F. and extends their life.

The long development of high temperature ceramic coatings was a difficult task with seemingly insurmountable problems. Basically, enamels are composed of three general types of materials: refractories, fluxes and opacifiers. The coating is usually fired to a vitreous coat at temperatures between 1,500° F. and 1,600° F. The first coat applied is a ground coat containing cobalt. The cobalt forms dendrites at the interface, anchoring the enamel glass to the metal. A second opaque coat is then applied to cover the undesirable blue colour of the cobalt. Since the enamel is fired

on within five minutes at firing temperatures, most of the enamel composition is fritted.

Frit consists of small friable pieces of glass which are produced by melting a mixture of oxides and discharging the hot melt into tanks containing water, quenching and shattering it. Prior to the quenching, all of the reactions mentioned above in the procurement of ceramics take place. Fritting makes alkalis insoluble and combines the water-soluble materials, such as borax, with silica. By the technique of fritting, it is possible to obtain a homogeneous glass which can be easily applied to a metal surface and which requires a very short period of heating before resuming its former smooth, flowing form.

In attempting to achieve an enamel that would withstand prolonged periods of exposure at temperatures of 1,700° F., it was realised that a very refractory enamel would be required. However, high temperature alloys have much higher coefficients of thermal expansion than low carbon steels. Unfortunately, high refractory materials, such as alumina, do not have as high a coefficient of thermal expansion as low melting point materials such as the fluorides. This posed a difficulty which was finally overcome in 1947 with the development by the Bureau of Standards of A-417. Because A-417 contains beryllia, which is very toxic, A-418 was developed in 1948 to replace A-417. In the A-418 formula, beryllia is replaced with zirconia and alumina. A-418 is an alkali-free frit which has a large admixture of chromium oxide that is added as a mill addition. Because it provides protection from high temperatures, it is called a ceramic coating rather than an enamel, which is used primarily for decorative effect.

The Ryan Aeronautical Company was one of the first companies to use high temperature ceramic coatings successfully and first to demonstrate their effectiveness in comprehensive flight tests. Arranged by Ryan with Boeing Airplane Company and Pan American World Airways, these flight tests were conducted on powerful Pratt and Whitney, 3,500 h.p. engines of Boeing Stratocruisers in trans-pacific runs. Ryan built sets of test

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exhaust header sections, from a number of alloys, coated and uncoated with ceramics, and subjected these to actual service on the aircraft. At intervals of approximately 500 hours, these headers were removed, taken to Ryan and examined by the development laboratories. Photomicrographs, spectrograms, microhardness readings and other tests were made of each header before it was returned to further service.

As a result, it was definitely shown that the ceramic coatings tested had substantially extended the life of the exhaust system components by protecting the metal surfaces against oxidation, carbon absorption and corrosion attack. These tests have continued until they are now approaching 3,000 hours of flight.

Also, similar sets of test headers have been installed on three other global airlines: United Air Lines, Northwest Airlines and British Overseas Airways Corp., in order to gather data from the use of the same components in Stratocruisers under different operating procedures.

These ceramic coatings permit the use of less critical materials in place of the scarcer alloys. Examples of this use are the inner combustion chambers for jet engines which can be made from Type 321 stainless steel and ceramic coated rather than from nickel-rich Inconel.

The ceramic coatings have to be uniform and exceedingly thin to prevent their cracking, chipping or flaking off from the surfaces. Average thicknesses run from .001 in. to .002 in. These coatings have withstood twenty cycles of immediate water quenches after being heated to 1,700° F. without deleterious effects. The thin coatings are an advantage to the weight-conscious aircraft industry, also, because of their lighter weight. They increase the weight of a typical part by less than 2 per cent.

A-418 undoubtedly has numerous possibilities in other industries. It has potential value in automotive and marine-type exhaust stacks and in industrial applications where high temperatures are utilised. It should be realised that A-418 is not a paint and must be applied by enamelling techniques. Proper application necessitates thorough cleaning prior to

coating, thin application of coating and proper firing procedures, all of which requires special technical experience and equipment. A-418 should not be considered a cure-all either. It cannot be applied, as formulated, to low alloy or mild steels. Research is now in progress, both in industry and at universities, on the development of a coating which will protect mild steels, at temperatures as high as 1,400° F. It is realised that great savings could be achieved in money and scarce metals, if mild steel could be used in place of stainless steels. It should be understood, however, by the designer, that mild steel, even when protected by ceramic coating, cannot be substituted for more expensive steels in many applications because of structural demands.

At temperatures of 1,600° F. and above, low-carbon steels have excessive creep and low tensile strength which render them unfit for these critical ranges. The ceramic coatings, being comparatively thin, do not insulate the base metal from the heat, though they do protect the metal from break-down from oxidation and corrosive vapours at high temperatures.

Combining ceramic oxides with metals, in order to achieve the desirable physical properties of both has led to the study of ceramic-metallic bodies, more commonly known as cermets. Ceramic materials, being oxides, are inert to further oxidation at high temperatures, but have poor thermal shock resistance and do not possess ductility. Metals, on the other hand, are ductile and because of high thermal conductivity are capable of releasing stress quickly, to withstand thermal shock. The idea of using ceramics with metals, in order to achieve a combination of physical properties, is not a new one. The reinforcement of concrete with iron rods is a common example.

Cermet bodies, however, are mixtures of the two, united in chemical bond by the use of intermediate compounds such as nitrides, borides, carbides, sulphides and hydrides. Considerable research on cermets has been done over the past few years. A review of literature on the subject provides a generalised picture of the problems and principles involved. The initial difficulty in the study of cer-

metals is the lack of data such as thermal expansion, conductivity, high temperature strengths, and corrosion resistance of the nitrides, borides and carbides. High melting point compounds and their use in cermets are being studied at many of the universities and research organisations of the country, as well as thirteen governmental agencies and over fifty industrial organisations. The approximate melting points of refractory com-

pounds are shown in Table I. Hafnium, tantalum, columbium and titanium carbides have the highest melting points of known compounds.

The development of cermet bodies seems to require the components to have a similarity of crystalline structure, similarity of radii of atoms and ions involved and similarity of bond types in order to form the resultant solid solution.

Direct chemical combination of

TABLE I. REFRACTORY MATERIALS WITH MELTING POINTS EXCEEDING 1,800° C.

(From "Refractory Cermets" by L. J. Cronin, Bulletin of American Ceramic Society)

Name	Formula	°C.	°F.
Aluminium nitride	AlN	2200	3992
Aluminium oxide	Al ₂ O ₃	2050	3722
Barium oxide	BaO	1923	3497
Barium zirconate	BaZrO ₃	2700	4892
Beryllium carbide	Be ₂ C	2100	3812
Beryllium nitride	Be ₃ N ₂	2200	3992
Beryllium oxide	BeO	2570	4658
Boron	B	2600	4712
Boron carbide	B ₄ C	2350	4262
Boron nitride	BN	2730	4946
Calcium carbide	CaC ₂	2297	4184
Calcium metazirconate	CaZrO ₃	2550	4622
Calcium oxide	CaO	2572	4662
Calcium silicate	Alpha-Ca ₂ SiO ₄	2130	3866
Carbon	C	3500	6332
Cerium oxide	CeO ₂	1950	3542
Cerium sulphide	CeS	2450	4442
Chromium carbide	CrC	1890	3434
Chromium dicarbide	Cr ₃ C ₂	1890	3434
Chromium sesquioxide	Cr ₂ O ₃	1990	3614
Hafnium	Hf	2207	4004
Hafnium boride	HfB	3062	5514
Hafnium carbide	HfC	4160	7520
Hafnium nitride	HfN	3307	5984
Hafnium oxide	HfO ₂	2812	5094
Iridium	Ir	2350	4262
Lanthanum oxide	La ₂ O ₃	2316	4201
Lanthanum sulphide	La ₂ S ₃	2100	3812
Magnesium aluminate	MgAl ₂ O ₄	2135	3874
Magnesium oxide	MgO	2500	4532
Molybdenum	Mo	2620	4748
Molybdenum carbide (mono)	MoC	2570	4658
Molybdenum carbide (di)	Mo ₂ C	2380	4316
Nickel oxide	NiO	2090	3794
Niobium	Nb	1950	3542
Niobium carbide	NbC	3500	6332
Niobium nitride	NbN	2050	3722
Osmium	Os	2700	4892
Rhenium	Rh	3000	5432
Rhodium	Rd	1996	3625
Ruthenium	Ru	2450	4442
Samarium sulphide	Sm ₂ S ₃	1900	3452
Scandium nitride	ScN	2650	4802
Silicon carbide	SiC	2537	4599
Silicon nitride	Si ₃ N ₄	1900	3452
Strontium zirconate	SrZrO ₃	2700	4892
Tantalum	Ta	2850	5162
Tantalum carbide	TaC	4150	7500

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Name	Formula	° C.	° F.
Tantalum nitride	TaN	3360	6080
Thorium	Th	1845	3353
Thorium carbide	ThC ₂	2773	5023
Thorium oxide	ThO ₂	2800	5072
Thorium zirconate	ThZrO ₃	2800	5072
Titanium	Ti	1800	3272
Titanium carbide	TiC	3140	5716
Titanium nitride	TiN	3220	5860
Titanium sesquioxide	Ti ₂ O ₃	2130	3866
Tungsten	W	3340	6076
Tungsten boride	WB	2922	5292
Tungsten carbide	WC	2777	5031
Tungsten carbide	W ₂ C	2857	5175
Uranium	U	1850	3362
Uranium oxide	UO ₂	2176	3949
Uranium carbide	UC ₂	2260	4100
Uranium carbide	U ₃ C ₃	2400	4352
Vanadium carbide	VC	2827	5121
Vanadium nitride	VN	2320	4208
Vanadium sesquioxide	V ₂ O ₃	1970	3580
Vanadium tetraoxide	V ₂ O ₄	1967	3572
Ytterbium	Yb	1800	3270
Zirconium	Zr	1900	3452
Zirconium boride	ZrB	2922	5292
Zirconium carbide	ZrC	3532	6422
Zirconium nitride	ZrN	2982	5400
Zirconium oxide	ZrO ₂ (Badde- levite)	2700	4892
Zirconium oxide	ZrO ₂ (Zirconia)	2950	5342
Zirconium orthosilicate	ZrSiO ₄	1775	3227

a metal with a ceramic oxide, other than its own, is difficult because of differences in their atomic radii. Nitrides and carbides of the metals are therefore used, whose crystalline structure and atomic radii are similar to the ceramic oxide, thus forming a solid solution with the ceramic oxide. An example of this are the chromium-alumina cermets. The oxide of chromium oxide goes into solid solution with alumina, with the refractory properties of alumina being retained.

Control techniques and manufacturing procedures needed to achieve intergranular adherence and strength in cermets varies with the final properties desired, the design of the piece under study and the composition of the ceramic metal composite. Special equipment is also required for the processing and testing of cermet bodies.

The techniques used in the making of cermets are similar to powder metallurgy. In general, the constituents of the cermet are ground very fine, the powders being carefully selected for highest purity. The metal and ceramic powders are then inti-

mately mixed and hydrostatically pressed in a die to the desired shape. Waxes, or other compacting lubricants, are often added for strength and die lubrication. If lubricants are used, a dewaxing process is necessary prior to sintering. The cermet body is sintered at high temperatures in special furnaces such as molybdenum-wound, resistor furnaces. The sintering atmosphere is usually neutral or reducing. Sintering atmosphere must be accurately controlled for uniform results. The sintering range of the cermet is a function of the fineness of metal in the body, the amount of impurities (which lower the sintering range), pressure used in forming, rate of heating and type of sintering atmosphere used.

The sulphides, borides, nitrides and carbides are usually used to provide a continuous bond between the ceramic oxide and the metals since the atomic radii of metals are such that direct chemical combination of a metal with a ceramic oxide other than its own is rare. Therefore, intermediary compounds are used, whose crystal structures and atomic radii are

TABLE 2. COMPARISON OF PROPERTIES BETWEEN METAL AND SEVERAL CLASSES OF CERAMICS.

(From "Metal-Ceramic Composites" by J. H. Westbrook, *Bulletin, American Ceramic Society*)

Material	Refractoriness	High Temperature Strength	Ductility	Thermal Shock Resistance	Stability	Oxidation Resistance
Metals ...	Poor	Poor	Good	Excellent	Good	Poor
Oxides ...	Good	Good	Poor	Poor	Excellent	Excellent
Carbides ...	Excellent	Excellent	Poor	Fair	Excellent	Poor
Borides ...	Excellent	?	Poor	Fair	Excellent	Fair
Nitrides ...	Good	?	Poor	Fair	Fair	Fair
Silicides ...	Fair	?	Poor	Fair	Fair	Good
Sulphides ...	Good	?	Poor	?	Good	Poor
Phosphides	Fair	?	Poor	?	Fair	Poor

similar to ceramic oxides, to allow the combination of dissimilar components.

Examples of this theory are MgO-TiN-NiO cermets, investigated by Rutgers University, in which titanium nitride is used to promote metal wetting during sintering. The magnesium and nickel oxide to nickel metal, and then ground and mixed with titanium nitride. Upon further sintering, titanium nitride promotes a bond between the metallic phase, the nickel metal formed during sintering and the ceramic magnesium oxide.

Another illustration is chromium-alumina bodies, investigated by Ohio State University. The chromium oxide, created in the sintering, forms solid solutions with alumina and wets the chromium metal grains. In this case, an oxide of the metal is the intermediate bonding component.

The most refractory ceramic coating is generally considered limited to temperatures of approximately 2,000° F. Ceramic coatings mentioned previously have a softening point below that of the metal which it protects. However, if the coating has a softening point above that of the metal, it is possible to obtain a condition where the underlying metal melts away, leaving the ceramic coating intact.

Some cermet coatings have their plastic stage and melting point 2,000° F. above the melting point of the metal to which they are applied. Cermet coatings are from 50 per cent. to 75 per cent. powdered metal, by weight. This bonds the refractory ceramic oxide into a homogeneous coating

and bonds the coating to the base metal. The cermet composition is reground after sintering and applied to the metal surface by various techniques such as flame spraying, sintering in an atmosphere-controlled furnace or by torching after cold application.

A promising new technique, investigated by Battelle Memorial Institute, is the vapour deposition process. By this means, metal halides have been applied to metal, glass or ceramic bases at temperatures lower than 1,500° F. Practical commercial uses for this process, which is still in the laboratory stage, are many.

Through the combined efforts of the ceramicist, the engineer and the designer, full utilisation of jet propulsion and nuclear energy is close at hand. The developments in the high temperature field today will ultimately result in a greater industrial advancement, and a higher plane of civilisation in the world of tomorrow.

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BRUSHING MACHINES

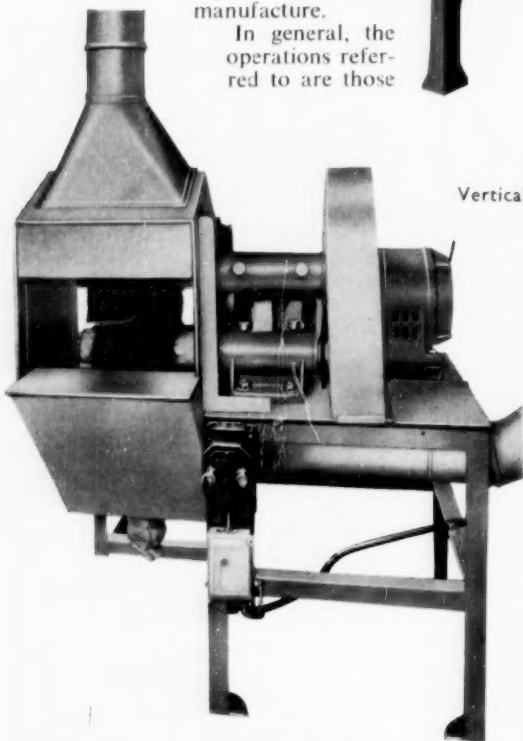
by T. WATHEY

WHILE the post-war movement toward fuller mechanisation of the pottery factory continues apace, there remain certain processes better done by machine which are still being performed by hand in traditional manner. This is a state of affairs which often operates to impede the flow of production by causing what has come to be known as a "bottle-neck," thus adding unduly to the cost of manufacture.

In general, the operations referred to are those



Vertical Double Brushing Machine
(Pat. No. 571,356)



Roller Flat Ware Brushing Machine. (Prov.
Pat. 7270/51)

which are considered to be women's work, either because the job demands delicacy of touch, or is of the kind which has traditionally been done by women because of the fact that the average woman, given a repetitive task of a light nature, is usually more conscientious in its performance than a man set to do the same job.

Hand Brushing

Among the pottery operations falling into the latter category is "brushing." The thorough brushing of "biscuit," prior to its "dipping," is vital

to the production of good quality ware. When done by hand, which is not uncommon, the work of brushing is done by women who carefully brush the ware clean of any material—sand, etc.—in which it may have been bedded during biscuit firing, and of any dust which may otherwise have accumulated.

Admittedly, the average operative does as good a job as can be expected, but consideration will show that in a modern factory "brushing" by hand is definitely a liability.

The average brusher works in a dusty atmosphere surrounded by piles of ware, sorted and unsorted, brushed and unbrushed—a scene which has been described as reminiscent of the market-place pot sales of a former day. Progress is slow, and the process occupies too much expensive floor space.

There is no need to say that dust in a pottery works is a danger, no matter in what department it occurs. Not only is it the bogey of the personnel management, but in addition, as

to review the work which is now being done by the brushing machines patented by Service (Engineers) Ltd., of Cobridge. There are two types of machine: the Roller Flat Ware Brushing Machine, and the Vertical Double Brushing Machine. Both machines have been proved on a wide variety of shapes and bodies, and have been found to produce satisfactory results.

Recent demonstrations of the two machines, gave an onlooker the impression that comparison of efficient machine-brushing with the hand operation is much akin to comparing the capabilities of a modern vacuum cleaner with those of the sweeping brush and dust pan.

In considering the Roller Machine, it should be understood that for the best results operatives must work as a team. On a factory visited, a group of three unskilled girls—all seated—were brushing and backstamping 2,000 doz. and over of flatware per day. The main feature of the machine is a pair of shaped, revolving brushes,



Courtesy: Messrs. Smeaton Ltd.

Roller Flat Ware Brushing Machine with Back-stamping Conveyor (Prov. Pat. 7270/51)

hand brushing is carried out under conditions where total extraction of dust is next to impossible, some brushed-off dust is almost certain to settle on goods which have already been through the brushing process—a happening which may well be suspected as one cause of disfigured ware.

Brushing by Machine

In view of this, it is of some interest

between which plates, saucers, etc. are passed. Dust and sand are thus removed, being exhausted via a hood and suitable dust-extractor fan placed above the brushes.

After passing between the brushes, the ware is delivered bottom up on to a chute, from which it slides in procession to a conveyor belt. This runs at a speed which allows backstamping of the ware in its passage to the "taker-off," who picks up the ware at

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the belt end and stacks it on either stillage or truck, as the case may be, when it is ready for removal to the dipping section.

It is claimed that the machine will brush the entire range of flatware with the exception of very deep articles, such as "soups" and "fruits." To cover this range, three sizes of roller brushes are supplied: small for saucers and $4\frac{1}{2}$ in.; medium for 5 in. and 6 in.; large for 7 in. and 8 in. It is also worthy of note that the conveyor has been found to be an advantage in another way. It can be used in the back-stamping of "fruits" and "soups" brushed by means other than the Roller Machine.

Combined Operation

At one factory, ware is sorted at a table adjacent to the Roller Machine, and the combined operations of sorting, brushing, back-stamping and stillage loading proceed smoothly and quickly at the hands of seated workers.

Advantages here lie in the fact that multiple handlings are eliminated, and a large average output per operative is possible because obstructions to flow production at this point do not now exist. Reports and thorough tests on

all kinds of flat indicate that the ware is well brushed.

The Vertical Double Brushing Machine, to which previous reference has been made, was designed to give high-speed brushing of "soups" and "fruits" of all shapes for which the roller machine is unsuited. It is also of value for use on small runs of flatware of all descriptions.

Figures of output vary with operatives, but the output of the machine is in many cases treble that of the single-head type. This machine consists of a cabinet carrying an internal electric-motor, which drives two revolving vertical spindles to which flat, circular brushes are secured. While the lower brush spindle is fixed, the upper is floating in order to allow of vertical movement of the revolving brush.

In operation, the ware-piece held in one hand is brought into contact with the revolving lower brush, the upper brush coming into brushing position by downward movement of the floating spindle. In this way, the ware-piece is held between the pair of revolving brushes for a period of time sufficient for adequate removal of dust and sand.

Thanks are expressed to Service (Engineers) Ltd. for their co-operation in compiling these notes.

Ceramic Raw Materials of India

IN a Symposium on "The Ceramic Raw Materials of India," organised on the occasion of the Silver Jubilee of the Indian Ceramic Society, at Banaras, between 7th and 10th February, 1954, forty-nine papers were presented. Prominent among the visitors was Professor W. E. S. Turner, F.R.S.

The Symposium focused attention on the raw materials available in India for the many ceramic industries and the lines of work engaging the attention of workers in India.

Indian Clays

The Geological Survey of India, in a recent survey, have located important deposits of clays and glass sands in parts of the country. There are deposits of

clays in almost every State of India. The five principal, sedimentary and residuary, clays of Hyderabad have been subjected to physical, X-ray, chemical and technological studies and are recommended for the manufacture of a wide variety of products. There are good clay deposits in Travancore and Mysore. The clays of Andhra have been classified geologically as to whether they are sedimentary in nature or products of alteration of felspars. The occurrence of nepheline syenites in many places of Madras, Andhra and Rajasthan States is recorded and it is pointed out that on account of the physical and chemical properties of nepheline, the rocks rich in this mineral can be used in the manufacture of glass and ceramics.

Lines of Work

Systematic investigations on the China clay deposits of West Bengal have shown that high grade clays with good P.C.E. values are available abundantly at Kharidumri and Dalamhija, the first being lean with a fixed shrinkage of 6.2 per cent. and the other with 12.5 per cent. There are also medium clays rich in iron oxide and titania and the iron-containing clays are recommended for the manufacture of cream coloured earthenware and stonewares. A study on the vitrifiable common clays of West Bengal has been made with a view to eliminate spots, patches and discolorations in bricks and tiles. Vitrified terra-cotta wares produced from the common clays have a good ring and can be conveniently coated with lac varnishes. The clay of Chandia in Uttar Pradesh has been found to be siliceous. The properties of Delhi clays are described. On the theoretical side, the measurement of ionic activity has been studied by "membrane electrodes," prepared from the swelling clays by evaporating into thin films and subsequent heat treatment; data have been presented on Indian clays and it is hoped these would be useful for ceramic chemists.

Sillimanite

Among other ceramic raw materials, sillimanite has long been known to occur in Assam. It is present in massive form as sillimanite or sillimanite-corundum rock, and blocks are sawn and used in large sheet glass tank furnaces. Field studies have shown that the sillimanite deposits can be considered to be lenticular in the form of segregations in the highly metamorphosed pelitic rocks. Sillimanite is also found in small quantities in the beach sands of Travancore along with zircon, quartz and other minerals. High grade zircon refractories have been manufactured from the pure and impure Travancore zircon. The pure zircon does not sinter readily and the bricks have to be fired above 1,500° C. for satisfactory results. Bricks possessing good underload properties may be obtained by firing them at low temperature if the zircon sand is precalcined at a high temperature, but such bricks have been found to be very porous and show excessive shrinkage. The impure variety of zircon gives a well sintered brick at 1,300° C. to 1,500° C. but they shear under load at 1,600° C.

Glass Sands

The sands from the banks of the rivers Ganges and Jumma and the sands from Madras and Travancore have been found to contain a fair amount of the oxides of iron and titanium and these can be removed by magnetic separation before the

sands are used in glass manufacture. The incorporation of naturally-occurring salt cake in place of soda ash in glass making has been successfully tried and amber glass has also been made.

Insulators

The occurrences of talc, graphite, gypsum and feldspar in India and their uses in ceramics have been detailed in some papers. A mineralogical study has been made to assess the suitability of serpentine and saxonite from Bihar for the manufacture of forsterite refractories and the optimum magnesite additions and the appropriate firing temperatures have been determined. It has been pointed out that, in view of the increasing steel production in India and the country's resources of chrome ore, it is desirable to prepare the chromite magnesite type of refractories. Electrical insulators are manufactured in Bangalore using the locally available raw materials and the suitability of Bihar Kaolin and ball clay for the manufacture of high tension insulators has been pointed out. In super duty insulation refractories, the multilayered of bladed kyanite at elevated temperatures and the volume changes accompanying the transformation are studied in detail.

Standards

The Indian Standards Institution have drafted standards for glass, refractories and some ceramic materials and have urged the proper enforcement of standards for putting better products on the market. The All-India Pottery Manufacturers' Association, which met concurrently, in addition to reviewing trends of trade, emphasised the rôle of the Indian Standards Institution for providing adequate standards and that of the Geological Survey for making a comprehensive survey of the pottery and ceramic raw materials of the country.

The British Ceramics Society.—The *Refractory Materials Section* will hold their Spring Meeting at the "Gleneagles" Hotel, Perthshire, Scotland, on the 19th to the 21st May, 1954. The second day of the meeting will be devoted to work's visits. Members will have the choice of visiting a steel works, aluminium works or refractory firebrick works. On the last day technical papers will be read on the theme "Aluminous Refractories—Their Manufacture, Properties and Use."

Pottery Exports.—The value of pottery exports in January this year was £1,039,197, compared with £906,567 in January last year. The volume of exports in January was 55,354 cwt., compared with 47,723 cwt. in January last year.

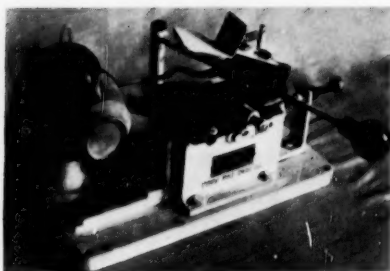
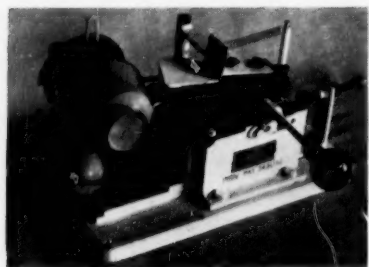
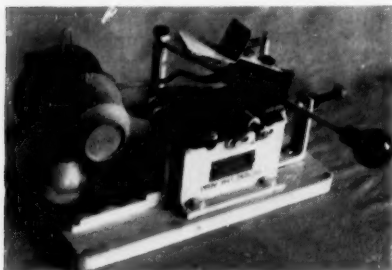
TWO RECENT DEVELOPMENTS

(1) A Simple Cup Handling Machine

(2) Mechanical Printing Press

(1) A Simple Cup-Handling Machine

While several first-class handling machines have recently appeared on the market it has been obvious that there is a potential demand for a small, inexpensive and portable type of machine which will handle cups quickly and with little skill on the part of the operator.



(Top) Fig. 1. (Centre) Fig. 2.
(Bottom) Fig. 3

Such a machine has been developed by Mr. Arnold Woolam of W. T. Copeland & Son Ltd., and is being produced by the Potteries Die Company, of Norton, Stoke-on-Trent.

The machine which is small in size can easily be transported and can be used on the normal work bench. The change from one shape to another is remarkably simple and takes only a few minutes. Means of varying the pressure applied are provided and cups on which the handle has to fit on specified marks create no difficulty.

Operation

The operation is as follows:

(Fig. 1) Slip is applied to the handle which is then placed in the flexible holder. The cup is placed on the chock. A pointer seen above the cup shows the exact spot to which the handle will be fixed. As the operating handle is moved towards the cup it first travels in the slot seen on the handle-holding assembly and this section (a) brings down the pad fastened beneath the right-angle plate into position to secure the handle firmly but gently in its holder (b) turns the cup through 90°.

As the arm continues to move forward it comes up against the end of the slot and moves the whole handle-holding assembly forward until it takes up against a resilient stop just as the handle meets the cup. The final pressure firmly fixes the handle to the cup.

(Fig. 2) The handle is moved away from the cup, first traversing the slot, this action lifting the handle-holding pad clear and then causing the cup to turn 90° in the reverse direction, bringing the handle to the positioning pointer.

(Fig. 3) As the handle comes up against the end of the slot the whole handle assembly is moved back into its original position ready for the next operation to take place.

As will be seen from the photographs the mechanics of the machines are extremely simple, there being little to go wrong and maintenance work required is negligible.

Fig. 4.
The Potteries
Die Co. mechanical
printing
press, designed
to fit on to
a work
bench



(2) Mechanical Printing Press

This machine was developed originally to take the hard work out of using the normal hand operated plank printing press as used with flat copper plates, in order to help the older operatives and also because of incidence of ruptures and similar disabilities among printers.

The machine is designed to fit on to a work bench and is operated by compressed air. The top roller as shown in Fig. 4 is the type normally used in a hand press. Three metal rollers of small diameter are situated on the base of the machine with the middle roller having the same centres as the top larger roller.

The top roller runs in bearings which are free to move up and down and which are spring loaded from below to give an upthrust. The end of a screw turned by a knurled knob rests on the top of the bearing and when turned pushes the bearing downward against the spring. This screw is provided with a lock nut. A pointer attached to the bearing moves up or down a scale to indicate its position and to help in giving an even pressure at each side.

When the top pressure is released from the bearings the roller is forced up by the springs and flannels can be removed, inserted or adjusted.

The metal plate on which the copper is placed is attached at its rear end by

means of a yoke to the piston of a cylinder situated beneath the base plate. This cylinder can be fed with compressed air at either end.

The air supply passes a lubricating device and is then fed to the control box. The small lever seen on this box is spring loaded. When this lever is pulled towards the operator the piston moves forward carrying the plate and copper away from the operator and between the rollers.

When the lever is released it springs back and the direction of the plate is reversed.

The speed of travel can be adjusted and when set gives, together with the present roller pressure, a good and consistent print.

This machine was developed by the Potteries Die Company and is manufactured by them at their Norton works.

Royce Electrical Furnaces Ltd.—This Company have recently produced an eight-page publication (R.F.5) describing and illustrating their Special-purpose High-temperature Furnaces. Their molybdenum furnaces are made in two ranges; the R.S. type for production of sintered metals including tungsten carbide and for bright heat treatment of special steels; and the R.M.T. type specifically designed for research, development and small-scale production.

Application of Electric Heating to Mesh Vibrator Screens

THE Long House Tileries of Messrs. Henry Hawkins Ltd., occupy a site of some five acres, where modern production methods contribute to an output of roofing tiles of some half million every week.

For some time past, their particular problem has been the screening of the tile clay after the grinding process, and until the successful engineering by Woden Transformer Company Ltd., Moxley Road, Bilston, Staffs, in co-operation with the engineers at Henry Hawkins Ltd., of electrically heating the screens, the problem was an awkward one, both from the point of view of continuous production, the life of the screens, and the unpleasant conditions attendant upon manual cleaning.

The ground clay was delivered by conveyor system to the vibrator screens in a damp condition, and after as little as ten minutes continuous operation the wet clay clogged the screen to such a degree that more than fifty per cent. of fines were being returned to the grinding plant.

Moreover, the screen had to be cleaned manually with wire brushes—a particularly wearing operation for the cleaner and for the screen.

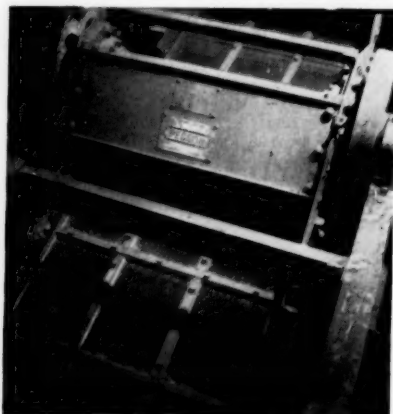
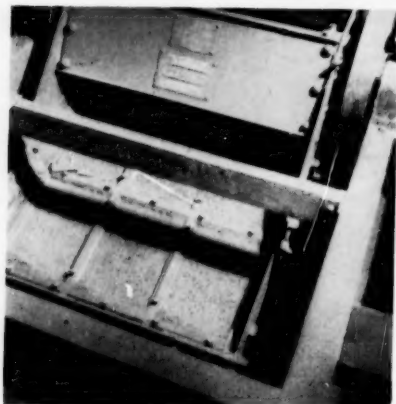
With this cleaning down process necessary every ten minutes during the

day, new screens had to be installed every week, and it can be imagined how much production time was lost from the point of view of cleaning, of replacing screens, and the inconvenience of half the ground clay being returned to the grinding plant.

Much effort was experienced in attempting to overcome this very great problem and various methods of heating the screens had been tried previously, including the blowing of hot air from fans on to the meshes, but success did not come until Woden Transformer Co. Ltd. engineered the application of electricity to the heating of the vibrator screens.

It has been found that the most satisfactory method of heating the mesh is to pass a heavy electric current through the mesh wires, at low voltage. The resistance of the wire raises the temperature of the mesh, thus providing a uniform heat over the complete area of the screen.

The current rating depends upon the size and mesh of the screen, the temperature of the clay and its moisture



The effectiveness of the system is illustrated here. (Left) The screen before heating. (Right) After heating

content, and to accommodate these variables a tapped transformer was provided giving six different current ratings.

The transformers used at Messrs. Henry Hawkins Ltd. are single-phase air-cooled types which had to be totally enclosed because of the fine clay dust which is generated by the vibration of the screens. The transformers are rated at 12 kVA, and Class "B" insulation was used because of ventilation difficulties caused by the necessity for total enclosure.

An ammeter is connected in the primary circuit and mounted in the transformer case.

In practice, it was found the tappings on the transformer would cater for a range of meshes on any given screen size, and therefore meshes can be changed if required, without the need for extra equipment.

The practical aspect of the installation proved to be a little difficult—mainly in overcoming the hazards of the continued vibration set up by the screens. The mechanical strength of the transformer and its leads had to be more than sufficient to overcome this vibration, and a positive measure of electrical safety had

to be guaranteed to the operatives. In addition, the distribution of heat over the screen had to be uniform, with reliable insulation of the meshes.

The installation with electric heating was first put into full production operation in August, 1953, and since that time it has not been necessary to replace the screen, and labour for cleaning down has been dispensed with entirely.

The screens now operate continuously, without supervision, and as much as 23 tons of clay per hour are going through them. Production has been increased by more than twenty-five per cent., and also the quality of the tiles improved.

The screen which was started on this process in August is still operating, and looks good for several more months to come.

It appears that the application of electricity to the heating of vibrator screens has solved the problem completely, and given more production and a better quality product.

The system is of course applicable to other materials and industries where screening is carried out, and where difficulties are experienced through moist material blinding the meshes.

Formation of a Sulphate Glass*

The ability of a compound to form a glass on cooling from its liquid state depends on the rate of cooling, the activation energy necessary for rearranging the constituents from the structure of the liquid to one of long range order, and on the difference between the free energy of the supercooled and the crystalline phase. The latter represents the driving force for the transition of the glass to the crystal.

If the rate of cooling is extremely high, that is, if the quantity involved is of microscopic dimensions, many salts can be obtained in vitreous condition which ordinarily would not be considered glass formers. G. Tammann and A. Elbraechter¹ obtained silver halides and some nitrates as well as chromates in the form of microscopic glass beads by using a method which ensured extremely rapid chilling from a temperature above the melting point to room temperature.

K. Fajans and N. J. Kreidl² pointed

out that the activation energy necessary for rearranging the constituents of a liquid into a crystal depends not only upon the strength of the binding forces but also on the symmetry of the constituents. Glycerol molecules, for example, exert upon each other only weak forces as can be seen from low melting point (M.P. 17°C.). Nevertheless, they form a glass on cooling because their configuration does not allow easy rotation and fitting of the molecules into a crystal lattice.

For binary compounds, V. M. Goldschmidt³ and W. H. Zachariasen⁴ derived certain rules for the formation of oxide and fluoride glasses. The controlling factors are ratio and sizes of the ions, their valency and their tendency to form either triangles or tetrahedra. On this basis, Zachariasen was able to predict the formation of Cb_2O_3 and Ta_2O_5 glasses. One of the chief requirements of glass formation is that the compound be able to form the random structure of a glass with its slightly distorted polyhedra, the energy content of which is not much greater than that

* From a report by T. Forland and W. A. Weyl, Pennsylvania State College, U.S.A.

CERAMICS

of the same ions in an orderly arrangement.

TABLE I

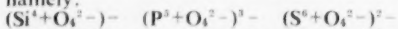
Increase of the Field of Glass Formation by a Combination of Two Different Cations

Ternary System	Per Cent.	
	Increase of Area of Glass Formations	
Na ₂ O - K ₂ O - B ₂ O ₃	15	
Na ₂ O - Li ₂ O - B ₂ O ₃	50	
Li ₂ O - K ₂ O - B ₂ O ₃	100	
Na ₂ O - K ₂ O - SiO ₂	30	
Na ₂ O - Li ₂ O - SiO ₂	50	
Li ₂ O - K ₂ O - SiO ₂	50	
Na ₂ O - K ₂ O - P ₂ O ₅	35	
Na ₂ O - Li ₂ O - P ₂ O ₅	15	
Li ₂ O - K ₂ O - P ₂ O ₅	50	

Glass technologists know from experience that the stability of vitreous phases, either glasses or enamels, can be increased if the number of glass constituents is increased. It has been recognised for a long time that more complex glasses usually have properties which are superior to those of simple glasses. Glass forming anions, e.g. (SiO₄)⁴⁻, (PO₄)³⁻ or (BO₃)³⁻ become distorted when surrounded by cations of widely different forcefields. Systematic studies on the fields of glass formation carried out by A. W. Bastress⁵ revealed that mixed alkali glasses extend much farther than one would expect from the composition in the symmetrical forcefield between H⁺ and K⁺. The proton probably penetrates the electron cloud of the sulphate anion, so that the deformed anion might be called a (HSO₄)⁻ group.

When KHSO₄ is kept at elevated temperatures in fused condition, water is gradually lost. After about half of the H⁺ content has been removed, SO₃ evolution starts and crystals begin to appear. The fused KHSO₄ can be supercooled easily; it has a long "working range" and can be drawn into fibres at a temperature as low as 70° C.

The KHSO₄ glass is water soluble and may not be of technical interest. However, its existence is interesting from the more than one theoretical view. In sulphate glasses the O²⁻ ions are exposed to the forcefields of the sixfold positively charged sulphur ions, which cause a strong polarization of the surrounding four O²⁻ ions. From this point of view the sulphate glasses go one more step beyond the phosphate glasses, namely:



The state of polarization of the O²⁻ ions directly affects properties such as light absorption of colouring ions, re-

ducibility of heavy metal ions (A_g⁺) and other chemical properties. Iron oxide, for example, imparts strong blue-green colours to a normal silicate glass. The absorption of Fe²⁺ and Fe³⁺ is much weaker in phosphate glasses and colourless phosphate glasses containing several per cent. of Fe₂O₃ have been obtained. Indeed, it was found that iron oxide dissolved in the KHSO₄ glass did not produce colour at all.

According to W. A. Weyl⁷, cobalt ions and nickel ions do not produce their usual blue and purple colours which are characteristic for silicates in certain phosphate glasses, but they give rise to a pink (Co²⁺) and yellow (Ni²⁺) colour respectively. The same colours were found for the sulphate glass. Among other colouring ions the yellow colour and strong fluorescence of the uranyl group might be mentioned.

The potassium-hydrogen sulphate offers an inorganic substance of simple composition which can be obtained in the glassy state and studied in a convenient temperature region.

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ELLIOTT BROTHERS (LONDON) LTD.

ELLIOTT Brothers (London) Ltd. announce that they have concluded a licence and technical agreement with the Bristol Co. of Waterbury, Connecticut, U.S.A., and have acquired the business of Bristol's Instrument Co., of Weymouth.

An official of Elliott Brothers has said that "productivity teams which have been to the United States to study the methods of their American opposite numbers have all reported on the wider use of instruments in the plants they have visited compared with those at home.

"Much of the instrumentation and control equipment they have seen has not been available in Europe without dollar imports. That is why we have taken this step to incorporate well-accepted United States designs in our range of equipment for British industry."

A New Ceramic Insulating Material

For the Manufacture of Aero-engine Sparking Plugs

A NEW ceramic insulating material for aero-engine sparking plugs, has been put on a production footing by K.L.G. Sparking Plugs Ltd. The new material "Hylumina" the manufacturers believe is a step in overcoming most, if not all, of the difficulties which can arise with plug insulators at high boost and in engines with high operating temperatures.

An efficient plug insulator must have five main qualities; (1) resistance to thermal shock, (2) good heat conduction, (3) poor electrical conduction under all engine conditions, (4) good mechanical strength and (5) resistance to tetra-ethyl-lead corrosion.

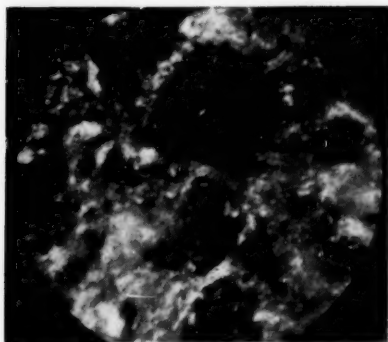
It is worth briefly explaining these properties, in order to appreciate the complicated conditions under which a relatively simple component like a sparking plug has to work.

Thermal shock can be defined broadly as the sharp rise and fall of temperature which occurs hundreds of times a minute in an engine. The

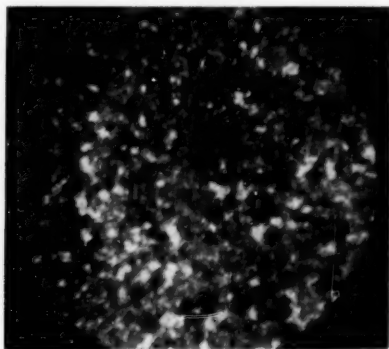
effects of sudden heating or cooling of household ceramics—cups and plates—must have often been noted with disapproval. In the same way thermal shock in aero-engines causes cracking of the plug ceramic; usually at the part of the insulator known as the nose, nearest to the combustion chamber.

Good heat conduction is required of an insulator in order that it may transfer quickly, the local heat away from the "hot spot" and to maintain as nearly as possible an even temperature throughout the length of the insulator. An excessive temperature change anywhere along the length of the ceramic leads to local stresses and often failure of the insulator.

It is almost unnecessary to say that the primary function of an insulator is to offer the maximum resistance to the path of an electrical current but, as will be seen, various factors can contribute towards the lowering of this desirable attribute.



Test slice of an old type ceramic. Microscope magnification by 170.8, print enlargement by 2, total enlargement 341.6



"Hylumina" section. Microscope magnification by 170.8, print enlargement by 2, total enlargement 341.6

CERAMICS

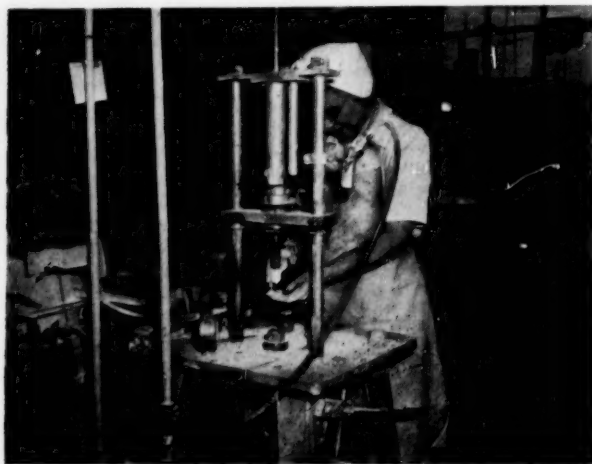
When the plug is assembled, the base of the insulator sits on a metal seat in the body of the plug and is clamped into position by a gland nut. Considerable force is exerted by this nut on the insulator, hence the necessity for a material with a high mechanical strength. In addition the insulators have to withstand the considerable effect of prolonged vibration and this alone caused the failure of plugs on one type of wartime engine until the vibration was effectively damped.

Tetra-ethyl-lead will form a lead oxide deposit on the insulator nose.

1930 and about three years later German chemists had produced a suitable material which was later produced in quantity for engine builders.

British companies quickly followed the lead and in particular K.L.G. produced a material, generally similar to the German ceramic, which with later minor modifications was used throughout the war. Briefly it was composed of the crystallised mineral, corundum, fired at a high temperature with "cement" which bonded the two materials together to form a hard, strong insulator.

This was more than adequate for



The fine grained materials making up the "Hylumina" compound are slightly damped and poured into a rubber mould. They are then compressed in the moulding machine into rough shape. The operator is removing the rough casting from the moulding machine spindle

It can eat into the insulator and combine with one of its materials to form lead silicate. This forms as a glazed surface over the insulator nose which besides being itself a relatively good conductor will form a gummy material which collects particles of carbon and dirt. This even further improves the chances of short-circuiting the plug. Lead oxides and lead silicate deposits are very difficult to remove once they have formed.

Background to Ceramic Insulators

Before the war mica was extensively employed as a sparking plug insulator but the introduction of lead impregnated petrol accelerated the search for a substitute insulating material. Mica stood up badly to the effects of tetra-ethyl-lead corrosion.

In Germany experiments began on a sparking plug ceramic as early as

the early wartime engines and for some time ahead but the limits of this material were seen soon after the start of hostilities and some experimenting began about 1941 to discover a more advanced material—which could be used on the big piston engines planned for the distant future.

It was found that alumina (aluminium oxide) was as nearly as practical an ideal material. The use of a fused pure alumina, however, presented heavy production penalties in cost and time. The experiments continued towards the discovery of a compound of alumina and other materials which would as far as possible retain the standards of a pure aluminium oxide insulator without its manufacturing drawbacks.

By 1948 a material known then as "S.749" was produced which appeared to have all the desirable qualities of



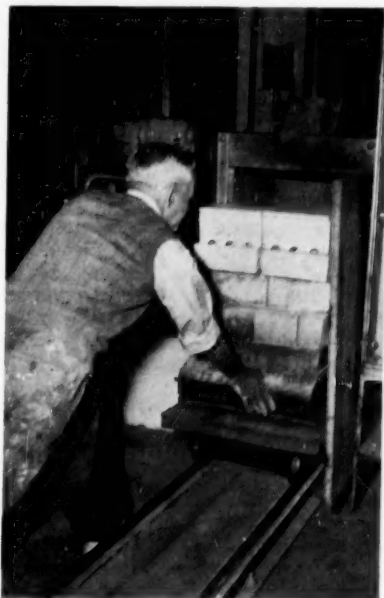
As the castings are still very soft great care has to be taken in forming the insulators. Tipped tools are used to turn the "Hylumina" compound

pure alumina without its disadvantages. This new material was composed of about 95 per cent. fine grained aluminium oxide, a bonding material and a little less than 3 per cent. of silica.

This third material acted as a flux for the other two although in fact if introduced in large quantities into the compound it has an adverse effect on the insulator's properties by helping to form lead silicate. The advent of the gas turbine gave an added impetus to the search for a new ceramic. Although the temperatures in the early jet engine were, very roughly, the same as those in the combustion chamber of a piston engine the trend of the turbine designers was towards engines with higher working temperatures. One of the dangers of employing a ceramic which might deteriorate under the effects of heat was that the bits of insulators which broke off would be blown into the turbine blades and could cause great damage. Once the new ceramic material had been produced it was submitted to The Bristol Aeroplane Co., and Rolls-Royce Ltd., for testing on their piston engines. Manufacturers tests are by necessity lengthy and exhaustive. They start in the most modest way by establishing a rating figure for the plugs on single cylinder engines. This rating figure is based on a manufacturer's formula. It establishes the factor of the plugs resistance to heat

and oil. Tests continue on the single cylinder engines to determine endurance, resistance to tetra-ethyl-lead and the erosion rate of the plug points.

Next, half the plug set of an engine



This trolley with two "saggers" hooks on to a conveyor which carries the "saggers" through the tunnel in 26½ hours. The temperature in the centre of the tunnel reaches 1,600° C.



Pairs of insulators their ends dipped in molten tin for 25 seconds over a temperature range from 600° C. to 900° C. The special four arm rig automatically moves the insulators into position and dips them for the correct time

in a ground test rig are changed in favour of the new plugs. Later all the new type plugs are used on the static engine.

This is the prelude to flight trials, first with half the set made up of approved plugs and the other half of the new plugs and later a full set is used. An engine manufacturer likes to accumulate about 25,000 plug-hours before granting provisional approval which has to be obtained before operational flight trials start. Once the manufacturer fully approves the plugs clearance by A.R.B. or M.O.S., for their use follows almost at once.

From these tests plugs with the following general characteristics were evolved for Bristol and Rolls-Royce engines; "Hylumina" insulators; a silver core fused to the platinum centre firing point; platinum alloy twin earth electrodes; a resistor of from 1,000 to 3,000 ohms; and a completely gas-tight joint between the insulators and the metal parts.

Slight modifications were required to the plugs designed for the Bristol engines to suit their special characteristics. They included the introduction of a bell-mouth end to the plug body to assist scavenging and to reduce the possibility of oiling when the engines were run at low power on the long-gentle-glide type of descent favoured by air lines.

The special qualities of "Hylumina" were soon required for igniter plugs and reheat plugs on the bigger jet

engines. Reheat plugs have to withstand temperatures of about 700° C.

In addition the new insulator is being used on a jet pipe thermocouple developed for use on Armstrong-Siddeley, Bristol and Rolls-Royce engines.

An interesting sidelight on the hardness of "Hylumina" is its limited acceptance for tipping machine tools. It is being used to turn plastics where a resistance to abrasiveness is most required.

Manufacturing Technique

In production the finely screened materials are compounded in mixers and slightly damped to give them a little cohesion. The mechanically mixed material is put into moulds and compressed roughly into shape. This cast is then formed into shape with a tipped tool and stacked in boxes for conveying to the furnace room. At this stage the insulators have to be handled carefully for they are still very soft.

In the furnace room the insulators are packed carefully in saggars. The "saggars" mounted on trolleys are coupled to a slowly moving conveyor through a gas-fired tunnel-kiln. It takes 26½ hours from the moment the boxes are dispatched at one end of the tunnel to the arrival at the other. During that time their temperature is slowly raised. They are fired for several hours at about 1,600° C. and then allowed to cool slowly.

This particular kiln is by Gibbons

Bros., Dudley, and gas consumption is approximately 720 cu. ft. per hour. Throughout their organisation K.L.G. use other gas-fired furnaces and these include, besides Gibbons Bros., installations by British Ceramic Service Co. Ltd., Stoke-on-Trent, and a German "Keabedars" furnace. The largest of these is a Bricesco unit consuming 1,000 cu. ft. per hour. It is interesting to note that these gas-fired installations account for a production of half a million insulators, of all types, a week.

At the end of the firing the insulators have turned a pale blue colour. They are all checked optically for flaws and a sample batch from each firing is subjected to a thermal shock test and compressive tests to destruction.

Plugs are first coated with Fuchsine dye then mounted on a special rig and

their noses dipped for several seconds in molten tin. Temperature of the tin is raised in 25° C. steps from 600° C. to 950° C. If the insulator cracks the Fuchsine runs into the split and it becomes readily apparent.

Next the widest point of the insulator is placed between the anvils of a compression testing machine and loaded until the ceramic breaks. The material always breaks along the major axis of the insulator.

Development of "Hylumina" has not stopped with its factory production for although it provides the answer to the problem of sparking plugs and igniters for some time to come there is as yet no sign of a stem to the flood of aviation developments and progress may well overtake the now new ceramic just as it did its predecessor. When that happens the next material will be ready.

Lead Exposure in the Pottery Industry

by Dr. W. SCHWEISHEIMER

(New York, U.S.A.)

RECENTLY several experts have shown differing opinions regarding the hazard of lead in the pottery industry as well as in other industries. For many years the danger of chronic lead poisoning, "plumbism," has been stressed and described in rather strong terms. This probably was necessary to inspire removal of old hazards, and to enlighten the minds of both employers and employees.

Now, however, we have been told by experts that, though caution with lead is needed, the dangers of its use may have been somewhat exaggerated. A defence of lead has been published by Dr. F. E. Wormser. It shows the effects that publicity of lead poisoning has had on the lay and medical mind. Numerous instances are given where widespread newspaper publicity has been given to deaths by "lead poisoning" which were afterwards shown to be due to other causes.

Making Glaze for Pottery

The use of lead is widespread in industry, but some of it presents no perceptible danger even over a period of many years. A dangerous source is lead in making glaze for pottery and tile, according to Dr. R. T. Johnstone in Los

Angeles, a foremost authority with regard to occupational diseases. He also mentions the lead hazard in enamelling of bathtubs, stoves, sinks, fixture and metalware.

This hazard is known wherever modern pottery producing methods are used. Recently a report has been made about lead poisoning in the Italian pottery industry by Dr. V. D. 'Onofrio. Much improvement has been brought about by substituting fritted lead for the soluble compounds formerly in use. Lead glaze, which was used for articles of pottery mosaic, contained about 40 per cent. lead as the borosilicate. Lead absorption and lead poisoning of the workers was due to inhalation of a fine dust from the dried glaze. Of the preventive measures the use of low solubility glazes was emphasised.

Lead Hazards Relatively Small in Industry

The lead hazard to the public is extremely small, Dr. Wormser points out, and is also relatively small in industry. Lead hazards can be effectively controlled when adequate care is taken. Diagnostic errors of lead-poisoning are frequent and understandable.

CERAMICS

Lead poisoning in the United States is rare, although this was not so fifty years ago. Such is the conclusion in a study by Professor Philip Drinker of Harvard Medical School. Industry is well-aware of lead's poisonous effects, and takes precautions. He says that danger from the use of products containing lead by the general public is dependent upon the length and the severity of lead exposure. But both severity and length of exposure have rarely exceeded allowable limits and have rarely led to trouble. Dr. Drinker warns that physicians too frequently diagnose symptoms as due to lead when actually lead is not involved. This applies to the diagnosis of lead poisoning in both industry and ordinary life.

"Plumbophobia"—Fear of Lead

In a recent study, Dr. Wm. C. Wilentz gave a warning against exaggerated fear of lead. Dr. Wilentz had the opportunity of observing many cases of lead absorption and lead poisoning at the National Lead Company, and at the Perth Amboy, N.J., General Hospital. The lead industries have been on the defensive far too long and unnecessarily. "The unfair and insidious propaganda which caused this situation," he says "has been permitted to permeate throughout the entire field of industry, government circles and courts of justice and has, therefore, placed the entire industry in a very unfavourable position. This is due primarily to the fact that too many men have written and are now writing too many books and articles about lead of which they know too little from a practical standpoint. These men, either innocently or by intent, are responsible for this condition which I term 'Plumbophobia,' meaning 'Fear of Lead'."

Such fears and impressions, Dr. Wilentz says, may have been justified some years ago, but they are not justifiable on any basis today. Industry is spending huge amounts of capital to install the most modern protective equipment, as well as providing the services of well trained physicians and modern medical dispensaries to deal with anything that may arise in the course of employment including the effects such as there may be from exposure to lead.

Recovery without Disability

Dr. Wilentz believes that cases of lead absorption and poisoning should recover without any disability. Sound medical observation and treatment together with present-day co-operation from management will obtain excellent results. Without this co-operation anything could happen. He is thoroughly acquainted with the possibilities of lead, but he warns us not to consider lead poisoning as an

"incurable disease." The exposures he saw, were from lead fumes and lead dust in combination with oxides, sulphates, hydroxides and antimony, the most common exposure being through inhalation of lead dust.

Here are some of Dr. Wilentz's conclusions. All cases of lead trouble must be in control of the plant physician or surgeon, as the treating of these cases requires particular experience. No re-exposure should be permitted without the consent of the medical department. Employees must be impressed with the importance of reporting all illnesses immediately to the medical department, so that relationship to exposure be ascertained quickly. Central eating places should be established.

Inhaled Lead

In the pottery industry inhalation of lead dust is the main hazard of lead absorption. Dr. Lawrence H. Cotter, of Columbia University, has seen many cases of lead poisoning by inhalation. Most important is to prevent absorption of lead.

Many a worker in the pottery industry with chronic lead poisoning went through all kinds of treatment. Dr. Cotter's patients had been treated by drugs; by laxatives; by injection with iron and calcium gluconate; by milk diet. In his opinion all these measures were of little effect on the lead. Dr. Wilentz advocates calcium treatment until a safer method has been found.

Dr. Cotter has prescribed the active pursuit of some outdoor hobby to keep his lead-patients' minds occupied, rather than the standard treatment by "rest" and drugs with plenty of time for introspection. One went deep-sea fishing, one resumed his old occupation of trapping in Canada, and several returned to the family farm.

After periods ranging from two to three months all were free from discomfort. Those who desired were able to return to their former industrial activity, as long as they avoided heavy lead hazards such as burning painted surfaces. We see here a confirmation of Dr. Wilentz's opinion that lead absorption and lead poisoning patients should recover with no resulting disability.

Dr. T. E. Gocher has reviewed the subject of lead poisoning from a clinical point of view. Different workers in the pottery industry differ in regard to resistance to lead and speed of onset. Inhalation of lead may produce symptoms of lead poisoning within hours. Ingestion by mouth will require about two weeks, and contact through the skin about two months.

Prevention is generally stressed as the best antidote to chronic lead poisoning.

INTERNATIONAL FURNACE EQUIPMENT CO.

Mr. Leon Bailly, M.Inst.F., for many years a director of the International Furnace Equipment Co. Ltd., of Aldridge, resigned from that position at the end of 1953 owing to increasing commitments on the Continent.

He will in future operate mainly in France and Belgium in conjunction with "Le Gaz Integral" of Paris, with whom the International Furnace Equipment Co. Ltd. is closely associated.

SOUTH AFRICAN NEWS

£100,000 Glass Factory Planned

Union Glass Ltd., of Talana, Natal, has bought a site at Bellville South, Cape Province, where it is intended to erect a £100,000 factory for the production of glass products. With its head sales office in Johannesburg, Union Glass Ltd. has eight sales offices in the Rhodesias and also supplies South-West Africa and the Belgian Congo.

Permanent Exhibition of Poole Pottery in Durban

A display of ware made at Poole Pottery has recently been installed at the Museum and Art Gallery in Durban. The exhibit will form part of a permanent exhibition, and typifies various aspects of the development of pottery at Poole.

German China Ware in Union

British Overseas Agencies, of Johannesburg, have been appointed South African agents for Bauscher Bros. Porcelain Fac-

tory, Weiden-Ober, Pfalz, Western Germany. Bauscher Bros. specialise in hotel and restaurant china.

Capital Increase

The capital of North Cliffe Ceramic (Pty.) Ltd., with head offices in Johannesburg, has recently been increased from £100 to £37,602.

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CHEST DISEASES IN THE POTTERIES

Conference at Stoke

A nation-wide campaign against air pollution and dust diseases reflects the country's concern with these problems. It opened recently with the first of a series of twelve conferences organised by the Socialist Medical Association in conjunction with the North Staffordshire Trades Council, Labour Party and Co-operative Party.

Dr. Joules, Superintendent of the Middlesex Hospital and Vice-President of the Socialist Medical Association, pointed out that, whilst the problems are general throughout England, they are particularly acute in the Potteries. It was essential, he maintained, to prevent diseases such as pneumoconiosis and silicosis. We had to treat the air as an open sewer, and when we infected or polluted it it was at our peril.

Mr. A. Goodwin, M.B.E., Assistant Secretary of the National Society of Pottery Workers, called for more stringent regulations at pottery factories. There were only three factory inspectors

in North Staffordshire to cover 2,500 factories. There should at least be 15. He would like to see dust extractors as used in Sweden installed in our factories.

Mr. Goodwin said that, in china production, silica had been taken out and substituted by alumina. He would like to see this introduced in all pottery ware.

WATER SPRAY

The Compton "Airless" water spray-gun illustrated here has possibilities in its application to the cup- and flat-moulding machines used in the mass production of pottery.

The gun is suitable for operation from pressures of 40 lb./sq. in. to 110 lb./sq. in., and may be coupled direct to water supply or to a Compton condenser attached to a steam return-line from any fixture. It is connected to supply by use of rubber hose.

A trigger stop-screw is provided, and this enables the weight of spray to be adjusted to particular needs. A double disc water-filter is incorporated, and is instantly accessible for cleaning, without the use of tools. In addition, a shut-off valve is supplied, and this enables the gun to be isolated from the water supply system.



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*Photograph of Floor Tile Intermittent
Kiln by courtesy of George Woolliscroft
& Son Ltd.*

Refractory Concrete Removable Flue-Cover, 5 feet diameter

REFRACTORY CONCRETE is Refractory aggregate bonded with Ciment Fondu high-alumina cement : is ready for use and of great strength and hardness in 24 hours : can be used to reduce joints to a minimum : can be cast to any shape : requires no pre-firing : is stable under load up to 1300°C : has a melting point of about 1450°C : has no appreciable drying shrinkage or after-contraction : can be brought to working temperatures 24 hours after making : does not spall under widest fluctuations of temperature : pre-cast blocks or special shapes can be made of practically any size or shape without distortion or cracking : uses old scrap firebrick to a very large extent : provides an ideal bond for setting firebricks.

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Correspondence

SAVE THE CHILDREN FUND

SIR.—Do you remember, how during the war, millions of working men and women gave a penny a week to help prisoners of war and the sick and wounded? In those days, people everywhere joined in a voluntary determination to relieve the sufferings of war.

Today, suffering is still going on, but it is little children who are now the main victims in an uneasy peace. Children without mothers and fathers, without homes. Sick, hungry children, older than their years, and all of them victims of war just as surely as were the prisoners and the wounded.

That is the debit side of the society's account. The credit side is fortunately brighter—more than half a million workers (including many in the ceramic industry) in Great Britain are helping to Save the Children, both at home and abroad, by paying a weekly penny.

There may be, sir, amongst your readers, those who would wish to know that the work of the Save the Children Fund is strongly supported by the Trade Union Congress and the great national unions; and there may be others who would wish to join in helping us to answer the cries of homeless, helpless children?

Most people will agree that one penny is not much in itself, but added to the pennies of others it may mean the difference between health and sickness, happiness and misery for children whose suffering, we are, and have been trying to relieve, day in and day out for the past thirty-five years.

Our simple aim is to encourage all

workers in industry to help with this great work. I know the Controller of the National Penny-a-Week Appeal will gladly furnish details, and help your readers to inaugurate the scheme in their own regions. The address is 20 Gordon Square, London, W.C.1.

Yours faithfully,

L. H. GREEN,

Chairman and Hon. Treasurer.

The patron of this worthy organisation is Her Majesty the Queen, and is president is Countess Mountbatten of Burma. The fund is trying to encourage an expansion of the "Penny-a-Week Scheme." It is hoped that the above letter from Capt. L. H. Green, will not pass without notice.
—EDITOR.

THE BEGGAR'S OPERA

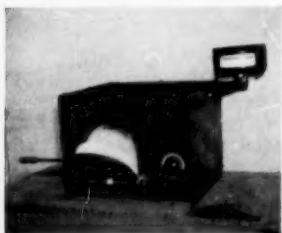
SIR.—For inclusion in Hinrichsen Edition's forthcoming publication of "John Gay and the Ballad Opera" the author is looking forward to the inclusion of photographs of china figures of characters from "The Beggar's Opera" created by British manufacturers.

Manufacturers who produced (at any time) figures from this famous old ballad opera are invited to write to the undersigned so that he might include some notice of such manufacturers in the publication in question. All photographs submitted will be safely returned after usage and full acknowledgment will be published.

Yours very truly,

GEOFFREY HANDLEY-TAYLOR,
F.R.S.L.

The Arts Theatre Club,
London, W.C.2.



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ASSISTANT LECTURER (POTTERY) required by **NIGERIAN GOVERNMENT** Education Department for two tours of 12-24 months or three tours of 10-12 months with prospect of pensionable employment. Commencing salary, etc., according to experience in scale £750 rising to £1,315 a year. Outfit allowance £60. Free passages for officer and wife and assistance towards cost of children's passages or grant up to £150 annually for their maintenance in United Kingdom. Liberal leave on full salary. Candidates should hold the Diploma in Pottery of the North Staffordshire Technical College and should be able to teach African students the theory and practice of pottery production and the classification and testing of clays. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M3B/34089/CU.

APPOINTMENT VACANT

HEAD DRAUGHTSMAN required by Liverpool engineering concern (having a small drawing office) specialising in the manufacture of presses and tools for powdered metal, ceramic, and other industries. Applications, from first-class draughtsmen only, should state age, education and experience. Box No. 31, CERAMICS, 157 Hagden Lane, Watford, Herts.

WANTED

CAPACITY WANTED for free bending and mould bending 18 oz. sheet glass sizes 5 in. diameter and rectangles 6 in. by 3 in.; finished glass to be suitable for silvering. Quantity required 10,000 assorted pieces per month. Box 32, CERAMICS, 157 Hagden Lane, Watford, Herts.

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R. Neil.—Robert Neil, director of J. and R. Howie Ltd., fireclay manufacturers, Kilmarnock, has died at Kilmarnock. He was for many years the firm's representative on the Continent and was well known to fireclay manufacturers and buyers there as well as at home.

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